PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

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CONTRIBUTED BY

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PREFACE.

The Editor has to apologise to the Subscribers for the late appearance of the present Volume. A lack of matter early in the year, and a press of it at the close, have been the causes of delay. Lord Napier, of Magdala, had intended to have contributed an article on the Abyssinian Campaign, but in consequence of the India Office having determined to publish an account of the expedition, he felt obliged to forego his intention: as it is, there are two papers on the subject.

There have been three Occasional Meetings since the publication of the last Volume; the subject of discussion at each having been the Moncrieff Gun Carriage. The report of the proceedings is so voluminous, and the last meeting took place so recently, that the present Volume would have become too large and have been still further delayed, had the Paper and Discussions been included in it. It will form part of the next volume, the publication of which will be expedited as much as possible.

Some interesting particulars relating to Prussian Siege Operations, are communicated by Colonel Lennox, R.E., in Paper XIII.

C. S. HUTCHINSON,
Lieut.-Colonel, Royal Engineers,
Editor.

Railway Department,
Board of Trade.
March, 1869.

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Page 63, Line 3	for "powered" read "powdered."	
„ 73, Lines 26, 27, 32	for "breaking" read "working."	
„ 74, „ 5, 6,	ditto	ditto

PROFESSIONAL PAPERS.

PAPER I.

DESCRIPTION OF A NEW EQUILIBRIUM DRAWBRIDGE, AND OF AN EQUILIBRIUM COUNTERPOISE FOR DRAWBRIDGES, &c.,

BY LIEUTENANT ARDAGH, R.E.

DESCRIPTION OF A NEW EQUILIBRIUM DRAWBRIDGE.

In 1862, having to make designs for a drawbridge, the author was struck by the general mechanical defects of these contrivances already in existence, and with a view to obviate them he devised the plan which is now described.

All the drawbridges hitherto constructed are either provided with counterpoises which more or less balance them; or if not, require the application of a considerable force to raise them. The span is necessarily much less than an engineer would elect to make it, were the choice free; 8, 10, or 12 feet being the usual length.

The interval between the standing part of the bridge and the gateway is so small that in the case of a feeble defence or a surprise, there would be little difficulty in crossing it.

To avoid this defect of drawbridges, long rolling bridges were introduced. Those in common use until recently, were open to the inconvenience that they often could not be moved at the moment they were required, from complication in the gear employed to work them. Indeed, until the introduction of Mr. Guthrie's bridge* (which is mechanically perfect, though presenting a few practical difficulties) it would appear that the rolling bridges were worse than the old drawbridges.

The drawbridge now proposed requires no counterpoises, and may be made twice the length of the old drawbridges with the same convenience.

The bridge O X, when down, is supported at the inner extremity by two keys O O, which may be made self-acting, but which it is better (for military

* Royal Engineer Professional Papers, Vol. XIII., page 14.

purposes) to work by hand; and at the outer extremity it rests as usual on the standing part. At the points B it is supported by the tension bars Y B, which have axes at each extremity.

When the bridge is raised it follows the motion indicated in the diagram, where it is shewn in an intermediate position $x y$, $x' y'$.

The point A represents the centre of gravity of the bridge, moving on the horizontal line X X', a condition which ensures equilibrium in every position.

The point of suspension B, moves on the circumference of the circle of which Y is the centre, and Y B the radius.

The points xy and $x'y'$ will then be constrained to describe the curves shewn in the diagram.

In order to investigate the general problem, let it be assumed that the bridge (at a certain intermediate position) makes an angle of φ° with the horizontal, and that the given quantities are represented as follows:—

$$\mathrm{A\,B} = a, \quad \mathrm{B}\,x'y' = b, \quad \mathrm{A}\,xy = c, \quad \mathrm{Y\,B} = r, \quad \text{and} \quad \mathrm{Y\,O} = p.$$

Then

$$y = c \sin\varphi, \ \because \ \sin\varphi = \frac{y}{c}$$

$$x = (a+c)\cos\varphi + \sqrt{r^2 - (p + a\sin\varphi)^2}$$

$$x = (a+c)\sqrt{1 - \frac{y^2}{c^2}} + \sqrt{r^2 - \left(p + \frac{ay}{c}\right)^2} \quad \ldots\ldots\ldots \ (1)$$

And

$$y' = -(a+b)\sin\varphi \ \because \ \sin\varphi = -\frac{y'}{a+b}$$

$$x' = -b\cos\varphi + \sqrt{r^2 - (p + a\sin\varphi)^2}$$

$$x' = -b\sqrt{1 - \left(\frac{y'}{a+b}\right)^2} + \sqrt{r^2 - \left(p - \frac{ay'}{a+b}\right)^2} \ldots \ (2)$$

The equations (1) and (2) are in a convenient form for calculation, and represent the curves shewn. As the end xy moves in the air we are only concerned to ascertain the path on which it is necessary to guide the inner extremity $x'y'$.

In the simplest form of bridges of this description, where the centre of gravity bisects the span, and the point of suspension meets the outer extremity of the bridge when raised,

$$a + b = c = p, \ a + c = r = \sqrt{c^2 + b^2}$$

Hence $(c - a)^2 = b^2 = (a + c)^2 - c^2$, or reducing

$$c^2 - 2ac + a^2 = a^2 + 2ac$$

$$\therefore c^2 = 4ac \text{ and } c = 4a = p$$

$$b = 3a \text{ and } r = 5a.$$

$$a : b : (c = p) : r :: 1 : 3 : 4 : 5.$$

This makes the calculations exceedingly simple, for substituting in equation (2) the values of the other constants in terms of a we have,

$$x' = -b\sqrt{1-\frac{y'^2}{(a+b)^2}} + \sqrt{r^2-\left(p-\frac{ay'}{a+b}\right)^2}$$

$$= -3a\sqrt{1-\left(\frac{y'}{4a}\right)^2} + \sqrt{(5a)^2-\left(4a-\frac{y'}{4}\right)^2}$$

In a span of 20 feet, a will be=2.5, and the equation takes the determinate form of

$$x' = -7{\cdot}5\sqrt{1-\frac{y'^2}{100}} + \sqrt{156\,25-\left(10-\frac{y'}{4}\right)^2}$$

which, for example, placing the value of y' at -6, will give

$$x' = -7{\cdot}5\sqrt{1-\frac{36}{100}} + \sqrt{156{\cdot}25 - 132{\cdot}25}$$

$$= \mp 6 \pm 4{\cdot}8 = \pm 1{\cdot}2 \text{ and } \pm 10{\cdot}8,$$

the co-ordinates of the four points on the curve to $y = -6$.

All the calculations are made in the same manner, and the curve may be set out either from the values thus obtained, or geometrically, or mechanically. The inner extremity of the bridge bears, through the intervention of trucks, on rails adjusted to the curve thus determined.

When it is altogether closed, its upper part occupies the exact position which would be required for a common drawbridge of half its span.

The force required to move it will be merely that which is needed to overcome the friction of the axes at Y, B & O.

The mode in which it is proposed to apply the force is an integral part of the scheme.

A rail, D C, runs through a ring at D, and works on an axis at C, attached to the standard and strut fixed on the bridge at this point.

A moment's consideration will show that when the bridge is up, the strut A C will lie in the position O D; and that the axis, in travelling from C to D, will describe a very flat curve, so that the rail may run through the ring at D with ease.

It is proposed to apply the force for moving the bridge to this rail, the power in small bridges being direct manual labour, and in very large ones the rail being drawn in by a winch and friction-wheel.

The absolute weight required to move a very roughly constructed model of the bridge, the platform of which weighed $6\frac{1}{4}$ lbs., was on an average 8 ounces, being $\frac{1}{12}$th of the weight put in motion. Any one who has seen the model will admit that the friction of the full-sized bridge is not likely to be proportionately so great; and in the experiment related the force was applied to one rail only.

The best experiments on frictional resistance will give a smaller result. Morin's co-efficient for cast iron upon wrought is ·07 and ·08. Taking the larger, and bearing in mind that the rail moves through 16 feet while the bridge moves 10, the necessary power would be

$$P = W \frac{10 \times {\cdot}08}{16} = {\cdot}05, \text{ or } \frac{1}{20}\text{th}.$$

Let the bridge be assumed to weigh 5,000 lbs. The force required to move it will be $\frac{5000}{12} = 416$ lbs. or $\frac{5000}{20} = 250$ lbs., according to the different hypotheses, or from 6 to 4 men—a number which would certainly be available to guard against contingencies. Gun-tackles may be provided to hook on to the eyes of the rails (or friction gear, as previously mentioned). One man on each side would then be sufficient to raise or lower the bridge.

The middle rail will move in a similar manner, but need not be employed for the working of the bridge.

The rails CE, joining the fixed with the moving parts of the bridge, are of iron pipe, fitting on studs, at either end, the long studs being at E and the short ones at C, so that if the bridge be closed, however suddenly, these connecting rails will merely fall off their studs, without interfering with its motion.

No particular dimensions are proposed for this kind of bridge, but it is suggested that 14 and 24 feet would be convenient limits, the former for sally-ports, the latter for large fortresses. They would then cover gateways respectively, 7 and 12 feet high. Of such small span are many of the existing drawbridges, that it would seem desirable, when any of the old platforms are renewed, to substitute bridges of this construction, which might be done at a very slight expense.

In applying this principle to dock, river, and canal bridges, it will most frequently be convenient to make the bridge in two parts, cambered in the centre, as shewn in the smaller section on the plate, where half the bridge is shewn in an intermediate position.

The standards in these cases will require to be but half the height necessary for the ordinary lifting bridge, and no counterbalancing weights are required; decided advantages when the opening is in the middle of a long lightly built bridge.

Here perhaps it would be better to raise the bridge by chains instead of by the rails C D, and to employ a second set of chains attached at OO for lowering it.

It is important to observe that C is the best point to apply a force to move the bridge either in or out, better even than the centre of gravity A; and that a force applied in the direction XY would be not so effective and much more troublesome.

A small 13-feet bridge is now being constructed at Newhaven Fort, on the principles herein described.

Description of an Equilibrium Counterpoise for Drawbridges, etc.

In the third number of the Corps Papers 1849-50, is a paper on drawbridges by Captain Galton, in which many varieties are described, and amongst others one in which the drawbridge while descending, lifts, by means of connecting chains, an internal gate in the form of a flap valve. General Lewis thought this the best proposed, and Captain Galton observes that its advantages are,

1st. Theoretically the counterpoise balances the platform in every position,
2nd. When the bridge is raised, the counterpoise acts as a gate.

The first claim cannot be admitted, as a short calculation of the moments would prove, and it is to be feared that disappointments may have arisen from such bridges not acting as they were expected to do wherever they have been erected.

Engineers have thought a good deal about the subject, as the multitude of different proposals indicate. Among counterpoised bridges we have those by Delile, Bergère, Poncelet, Lacoste, etc.; but no one appears hitherto to have hit on the following plan, which is described now, it is believed, for the first time.

The hoisting chains, attached to the outer end of the bridge, pass over pulleys as usual, and to their inner ends hang weights exactly balancing the bridge, when horizontal. Attached to the weights are pulleys working on the wire rope HGE, which is fixed at its extremities.

The pullies are thereby constrained to describe the elliptic curve, EGI, and the weights balance the bridge in every position. Nothing can be simpler; it is only surprising that no one suggested it before.

It remains to investigate the theoretical conditions of equilibrium, and to show that they are fulfilled in this proposal.

In dealing with the theory nothing but the points and lines are considered.

Let the horizontal line D C L be the axis of x, and D K that of y. Let the position F of the counterpoise, when the bridge is open, be distant a from the origin on the axis of y. Let $\mathrm{C\,O} = p$, $\mathrm{D\,G} = q$, and $\mathrm{A\,O} = r$, the radius of the circle described by the point O. Let the weight of the counterpoise be m times the weight of the bridge, m being a constant dependent on the position of the hoisting chains. Let x, y, be the co-ordinates of the point G; $x'\,y'$ those of the point O; and θ, the angle made by the line D G with the axis of x.

The condition of equilibrium—that the centre of gravity should move on a horizontal plane—necessitates that

$$\mathrm{W}\,dy' = -m\,\mathrm{W}\,dy \qquad (1)$$

integrating and adding the constants,

$$r - y' = m\,(y-a)$$
$$y' = r - m\,(y-a) \qquad (2)$$

By the equation of the circle

$$x'^2 + (r-y')^2 = r^2 \text{ or } x'^2 + y'^2 = 2ry';$$

$$\text{but } p^2 = x'^2 + y'^2 = 2ry' = 2r\left(r - m\ (y-a)\right)$$

The length of $p + q$ is obviously constant and equal to $r\sqrt{2} + a$, substituting $r\sqrt{2} - (q-a)$ for p, we have

$$\left(r\sqrt{2} - (q-a) \right)^2 = 2r^2 - 2rmy + 2rma$$

$$2r^2 - 2r\sqrt{2}\,(q-a) + (q-a)^2 = 2r^2 - 2rmy + 2rma$$

$$2rmy = 2r\sqrt{2}\,(q-a) - (q-a)^2 + 2rma \quad \ldots\ldots\ldots\ldots \quad (3)$$

or substituting q sin. θ for y,

$$2rmq \sin.\theta = 2r\sqrt{2}\,(q-a) - (q-a)^2 + 2rma \quad \ldots\ldots\ldots \quad (4)$$

It is easy to perceive that the element of uncertainty, a, may always be eliminated by the addition of another pulley; the equation (3) then takes the form—

$$y = q \sin\,\theta = \frac{\sqrt{2}}{m}\,q - \frac{q^2}{2\,mr} \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

Dividing both sides by q, we have—

$$\sin\,\theta = \frac{\sqrt{2}}{m} - \frac{q}{2mr} \text{ and if } m = \sqrt{2}, \text{ then } \sin\,\theta = 1 - \frac{q}{2r\sqrt{2}} \quad \ldots\ldots \quad (6)$$

an expression easily computed, and one which may conveniently be used for the construction of the curve, which will then in all cases be the quadrant of an ellipse, of which $2r\sqrt{2}$ and $r\sqrt{2}$ are the axes.

From these equations the whole properties of the curve may be evolved. It is simplest constructed, however, geometrically, by dividing the chord C B into any number of equal parts, and with C as a centre describing arcs intersecting the quadrant. From the points thus found, draw lines parallel to A B, intersecting any vertical line M L. From M set off M N, such that its length shall bear the same proportion to the height through which the centre of gravity of the platform is lifted, as the weight of the platform bears to that of the counterpoise.

Join L N, and draw lines parallel to it, dividing M N proportionately to M L. From the point F, set off F K, equal and similarly divided to M N. Draw horizontal lines KI, &c., and with D as a centre describe arcs commencing with the radius D F, and increasing by the equal parts into which C B has been divided. The intersections will give points on the curve. The foci may also be found by construction in the usual way.

In practice it will be better to have the curve more hollow in the middle than theory requires, in order to get over the vis inertiæ of the structure. This will be more convenient, too, in respect of the guide being shortened.

A model has been made of this bridge, which works with the greatest ease. It is believed that there are still many drawbridges without even an attempt at a counterpoise, and it is suggested that this plan should be applied to them. The weights may be placed anywhere, but the passage is the most convenient place, as both they and the guide ropes hang high up out of the way when the bridge is down.

Feb. 1868. J. C. A.

PAPER II.

REPORT ON THE EXPLOSIONS AT THE MARSH POWDER WORKS, FAVERSHAM, ON THE 28TH DECEMBER, 1867.

BY CAPTAIN CORNES, R.E.

Inserted by permission of the Director of Works.

The Marsh Powder Works of Messrs. Hall, are situated on the borders of the marshes in the neighbourhood of Faversham, and are about one and a half miles from that town.

The Plan B, shows in block the arrangement of the buildings composing these works. The factories in which the explosions took place are shown in more detail on the Plan A.

In the manufacture of the powder, the raw charges were brought by road from the incorporating mills to the charge house, from thence they were taken to the press house, and so on by boats on the small canal.

The explosions occurred in the charge house, the press house, and the granulating house.

The charge house was a small strongly built brick building with an arched roof, and resembled a small magazine.

The press and granulating houses were weather-boarded buildings on brick foundations, and had light boarded roofs covered with slates. The boiler and engine houses had brick walls and slate roofs. The glazing house was weather-boarded like the press house, but it had a flat roof, arranged so as to form a series of shallow tanks holding about 5 inches of water.

The press and granulating houses formerly had similar roofs, but from their constantly getting out of order and requiring repair, as well as from their tendency to leak, which made it difficult to clear off the powder dust from the ceilings, they had been removed and replaced by boarded slate roofs, as described. These factories were about 80 yards apart, and were partially enclosed by traverses and walls as shown on Plan A. The walls were carried across the rear of the factories in two instances, on the side next the town of Faversham.

The front facing the marshes, was left open, with the view of having lines of least resistance in that direction to the forces of any explosions.

These walls were 22 feet high, 6 feet thick at the bottom, and 3½ feet at the top, with a saddle coping; they were roughly built, and were not strengthened in any way with bonding iron. They were occasionally re-inforced with buttresses, whose positions are shewn on the plan.

The traverses were about 27 feet high, 6 feet wide at the top, and 60 feet wide at the bottom.

The boiler and engine, of 30 horse-power, worked the machinery in the granulating and glazing houses and the hydraulic press in the small building outside the wall of the press house, by horizontal shafts passing through arched openings, 3 feet wide and 4½ feet high, under the traverses. These openings, though necessary for the proper working of all the machinery by one engine, prevented the complete isolation of the factories from each other. In this instance, however, it seemed improbable that any flame or embers had passed through the openings, as no traces of their passage were to be found in the straw which covered the shaft, to protect the latter from the effects of frost.

It is uncertain what quantities of powder were exploded in the several houses. The foreman states that there were 16 or 17 cwt. altogether in the press and granulating houses, and 6 or 7 cwt. in the charge house. But as the quantity allowed at one time in each of the two former houses is, by the factory rules, only limited to 20 cwt., and as it is known that of the two presses in the press house one was fully charged, the probability is that the quantities stated are a very moderate estimate of those actually exploded. It is, however, not of very great importance to know the quantities, unless we know also the exact circumstances of explosion, or at least the exact disposition of the material at the moment of ignition. For instance, the quantities of powder in the press and granulating houses were probably nearly equal; but in the first house it was in bulk, one press being full, and under high pressure; in the second, the powder was dispersed, and was not under pressure: now, the destruction caused by the explosion of the first was much greater than that of the second.

The primary cause of the explosions is as yet a mystery; but from the three distinct reports which were heard on all sides, by many people and at various distances, they must have been, not simultaneous, but successive. The eleven men who were in the buildings blown up were killed. The foreman and one of the boatmen, both of whom were in the immediate vicinity, give opposite opinions as to the priority of the buildings in the order of their explosion, one believing the press house was the first, the other stating that he saw only the flash from the explosion of the granulating house, by which he was rendered insensible. The charge house was most likely not the first, as from its containing the smallest quantity of powder, it would probably not have produced sufficient force to explode the other houses; and it was more liable than they were to be fired by a previous explosion, as the door was open, and a charge in course of conveyance between it and a boat on the canal. The probable cause of the successive explosions will be referred to again.

EFFECTS PRODUCED.

Charge House. This building was demolished, and its site covered with the debris of the buildings and of the adjoining wall, a portion of which, for a length of 30 feet from the end, was entirely removed. The surrounding plantations of young trees were mown down, and large elm-trees on both sides of the public road were cut off or uprooted for a distance of 40 to 50 yards. Fragments of the wooden buildings, mostly charred, were thrown around in all directions, and to considerable distances, while brickbats were scattered upwards of 600 yards away.

Press House. This house was destroyed to the foundations. Its enclosing wall was much damaged. In addition to the portion removed (referred to above), the rest of the wall showed horizontal fractures throughout its thickness, running round at a distance of 10 to 12 feet below the top; and the portions above these fractures were pushed outwards, in some places nearly 12 inches. Many vertical cracks were also shown, and the upper half of the buttress at the back of the wall was thrown down. The traverses were not damaged, but the shrubs and briars previously growing on their interior slopes were swept down.

Outside the entrance of the press house enclosure was a small building containing the machinery for working the hydraulic press. This building had its slate roof stripped.

In the interval between the enclosures of the press and granulating houses some of the young trees were cut down by the fragments of the buildings falling on them; but no damage appears to have been directly caused by the force of the exploded powder passing over the traverses.

Granulating House. This house was entirely destroyed, but the damage done to the enclosure walls was slight. There were vertical cracks, about 2 feet deep, below the top of the wall, at the angles; and the sloping course of bricks was blown away nearly all round the inside of the walls. This course was scattered around in all directions; in some cases, portions several square feet in area fell together, the junction of the bricks and mortar remaining intact.

No portions of the machinery in these houses appeared to have been projected far from the enclosures.

Boiler and Engine Houses. These were in the interval between the enclosures of the granulating and glazing houses. The walls of the boiler house were about 8 feet, and those of the engine house about 24 feet high. Both had slated roofs.

The walls of the boiler house were started outward about 4 inches at the top. This may have been caused by the force of the exploded powder passing through the shaft opening, likewise over the traverse and through one of the doorways; the roof thus shaken at all its bearings, and also sustaining outward pressure, appears to have collapsed and thus fell within the walls. The slates were stripped from the roof of the engine house, and one or two rafters disturbed. After the explosions, the engine still continued to

turn the shaft communicating with the glazing house, but the foreman at once turned off the steam from the boiler and disconnected the shaft, thereby avoiding the risk of an explosion in the glazing house.

Glazing House. Here the damages were limited to the fracture of some of the rough plate glass window panes, and to the stripping of a portion of the weather boards from the side and end next the shaft opening. Small pieces of charred timber fell on the tank roof, but none were of sufficient size to injure it. A lean-to shed on the side next the canal had its rafters shaken and slightly displaced.

Distant Buildings. Those containing the offices, the incorporating mills, and the work shops were on ground gradually rising from the level of the factories, and distant 200 to 250 yards from them. The walls of many were from 20 to 25 feet high, and they mostly had ridge roofs, covered with slates or tiles, and projecting eaves. Many window panes were broken, and a large portion of the tiles and slates of the roofs were displaced, more particularly on the sides next the factories. The extent of damage done to the roofs was variable. For instance, in some cases the slates were stripped in large irregular patches at some distances apart; in others, the tiled roofs had their coverings shaken off in horizontal lines for two or three courses. In all these cases the loosened slates and tiles merely slid over the roofs and fell in such a way that no injury would have occurred to anyone, unless standing close to the walls.

Some farm buildings about 300 yards from the charge house, on the opposite side of the road and rather below the line of the canal, shown in Plan A, had their tiled roofs damaged and windows broken. Slight damages of this nature were likewise sustained by the remaining buildings of the powder works.

The comparatively small quantity of powder exploded, and the relatively great distance of other buildings from the site of the explosions, confined the damage done to that described above, and to a few other isolated cases of broken windows.

Remarks.

If reference be made to Plan A, it will be seen that the press, granulating, and glazing houses, were at intervals of about 80 yards from centre to centre, and it is probable that the one of the two former houses which exploded first caused the explosion of the other by the projection of fragments of charred timber through the roof of the latter; by this means either admitting burning embers, or so deranging the machinery as to induce sufficient friction to cause ignition, and thus exploding the charge present. For it is not probable that the powder in one factory could have developed sufficient force of concussion to open the roof of the next and so expose the charge, as in that case the glazing house would have been so affected, whereas its roof was uninjured. Now, the only difference in the intervals on the right and left of the granulating house was that the former contained the boiler and engine house, but this can have had little or no effect in diminishing the force of the explosion on that side; for if, on the one hand, they formed additional obstacles to the passage of that

force, they, on the other hand, filled up space in which the gases of the exploded powder and the concussion of the air produced by them might have been expended or diminished.

It is, therefore, fortunate that no heavy fragments of timber fell upon the roof of the glazing house, for though the water in the tanks might have put out some of the embers, yet the roof itself might have been penetrated as readily as those of the other factories, and the charges present would have been as much exposed to risk of explosion.

INFERENCES.

Neighbouring Buildings to Factories.

All buildings near enough to powder factories to be injured by explosions, should have their walls carried up so as to catch the debris from the roof, in the event of the latter being stripped.

The pitch of the roofs should be a medium, as if it be steep it facilitates the sliding of the slates or tiles; if it be flat it offers less resistance to stripping.

Factory Buildings.

The roofs should be so constructed as to avoid the use of timbers of such scantling as would render their fragments destructive to the roofs of the adjoining factories. As such roofs should be moderately light, so as not to require strong supports, and in order to offer little resistance to any explosion beneath them; and, further, as the inside of the factories should be boarded to prevent the condensation of moisture on the surface of the walls and ceilings, it is conceived that a good construction would be obtained with brick walls lined with thin boarding nailed to battens, and having galvanized iron roofs upon principals of wrought iron rods and T iron. These would be capable of supporting a ceiling of thin boards, which would be readily destroyed by the force of an explosion within; and the gases passing through the open ironwork, would not be likely to project any dangerous fragments around.

The dimensions of the walls, traverses, and intervals of the enclosures at the Marsh Works appear sufficient, if the defective construction of the roof be avoided.

If no buildings are near the factories, it would probably be better to have both the front and rear of the latter open, making the traverses at the sides as long as convenient.

In this case, no doors, windows, or openings, should exist in the walls of the factories next the traverses. These walls should also be stronger than the others.

All the timber essentially requisite in the machinery of the factories should be connected by iron rods passing through each piece, so as to avoid their being projected to any great distance.

So vast a difference exists between the forces generated by the explosion of the largest charges of powder usually treated in factories, and of what would be a moderate amount in a store magazine, that it is not considered that pertinent inferences bearing upon the construction or positions of magazines can be drawn from the casualty herein reported on.

J. E. C.

Jan. 16th, 1868.

PAPER III.

SKETCH OF MILITARY PROCEEDINGS IN NEW ZEALAND,

FROM THE TERMINATION OF THE WAITARA CAMPAIGN, IN MARCH, 1861.

By Major General Mould, C.B., Late Commanding Royal Engineer in the Colony.

As a preliminary to a Sketch of the Military Proceedings in New Zealand, subsequent to March, 1861, it may be shortly stated, that in the month of March, 1860, operations were commenced against the rebel natives in the Province of Taranaki, near the river Waitara, about 9 miles north of New Plymouth, the chief town of the province, and were carried on both north and south of the town, until the 18th March, 1861, the latter part of the period being occupied in operations directed against two strong inland positions, which the enemy had taken up at Huirangi and at Te Arei.* The last shot was fired on the evening of the 18th March, 1861. Early on the following morning the rebels hoisted a white flag; in consequence, the native secretary with another government official, and some friendly native chiefs, went to the enemy's lines and conferred with William Thompson, and the other rebel chiefs. The result of this conference was that the mass of the rebels retired to their own districts.

Shortly after, the governor, accompanied by two of his ministers, arrived at the Waitara, and the latter had several conferences with the rebel chiefs, which resulted in the adhesion of a portion of them, under the Chief Hapurona, (Absalom), the great fighting leader, but William King, the prime mover of the war, still held aloof.

It may be here explained, that there were three parties engaged in the war; 1st: the natives from the Waikato District, who were the representatives of the Maori King; 2nd: the natives who inhabited the district about the Waitara; 3rd: the natives inhabiting the southern part of the province of Taranaki, who entered into the war for the mere pleasure of fighting, and to get plunder. William Thompson, the prime councillor of the Maori King, belonged to the first of these parties; William King and Hapurona to the second.

* These operations are described in Vol. XI., of the Royal Engineer Professional Papers.

To each of these parties separate terms of peace or submission were offered, varying according to the part taken by each in the war, but generally requiring "Entire submission to the Queen and the law; the restitution of, or compensation for, plunder; and an acknowledgment of the right of passing through every part of the country without interruption or molestation."

Whilst the conferences with the natives were proceeding, Lieutenant General Cameron, C.B., arrived (30th March) from England, to assume the command of the troops in New Zealand, and Major General Pratt, C.B, previously in command, returned to Victoria, Australia.

At this time the military force was in occupation of the town of New Plymouth, and of only a narrow strip of ground along the sea coast, about 15 miles in length. The posts held to protect the district, which was still unsafe, were five in number, exclusive of a large stockaded barrack in New Plymouth, and seven blockhouses round the town.

The force in the province on the arrival of Lieutenant General Cameron, amounted to about 2,300 of Her Majesty's troops, and between 400 and 500 Militia.

In the latter part of the month of April, a considerable number of troops were removed to Auckland, leaving about 850 regular troops in the province of Taranaki.

At the end of May, a stockade called Matarikoriko, in the Waitara district, was given in charge to the Chief Hapurona, who was promised a salary of £100 a year for taking charge of it, really a bonus to keep him detached from the war party.

Nearly 3,000 men were at this time concentrated in the Province of Auckland, two thirds of them being encamped on ground near the town of Otahuhu, about 9 miles S.E. from the City of Auckland, on which huts for the whole were afterwards erected.

The formation of a Transport Corps was at this time commenced, the officers and men being drafted from the different regiments in the command.

The corps on the 1st July, 1861, consisted of 1 director, 3 officers, 1 staff, 2 sergeants, 1 bugler, 43 privates, 18 horses, 30 bullocks; but subsequently and especially after the recommencement of hostilities in 1863, it was very considerably augmented, eventually comprising an establishment, exclusive of the director, of 44 officers and staff, 134 N. C. officers, 1,348 privates, 2,244 draught animals.

Matters remained quiet for some months, but negotiations with the natives were being carried on with the view of placing the relations of the two races, Europeans and Maori, on a more satisfactory footing, for though hostilities had ceased at Taranaki, yet there was not the least sign of a recognition of the authority of the Queen in any part of the country.

His Excellency, Sir George Grey, who was transferred from the Government of the Cape of Good Hope to that of New Zealand, in consequence of "his peculiar qualifications and experience" in the management of uncivilized races,

assumed the government in October, 1861. He went a short distance up the Waikato River in the month of December, and on his return requested the Lieutenant General Commanding, to undertake, by the troops, the formation of a road from Drury, a town about 22 miles South of Auckland, to the nearest point of the Waikato River.

Every available man was moved out from Auckland and Otahuhu, and the work was commenced on the 1st January, 1862, $10\frac{3}{4}$ miles being completed, including the metalling, by the beginning of June. The Lieutenant General was personally present at Drury, during the whole time the work was in progress, to direct its execution, which was performed under the superintendence of the Royal Engineers.

The formation of this, called the Great South Road, was a very important and indeed necessary work, both in a commercial and military point of view. For military purposes, the road was absolutely essential, if it became, as it did afterwards become, necessary to carry on hostilities in the Waikato country.

The Commanding Royal Engineer submitted first to the Lieutenant General and subsequently to the Governor, a Memorandum in reference to the construction of roads, which was considered of sufficient importance to be adopted as a public official document, a copy having been forwarded to the Secretary of State for the Colonies, and also laid before the houses of the colonial legislature; a copy of this paper is appended (marked A), and it is believed to have originated the idea of undertaking the construction of the road before referred to. The cost of the road was about £2,930 per mile.

The road being completed, the troops returned to their quarters with the exception of 550 men, 500 of whom were posted near the Maori village of Pokeno, to undertake the construction of a redoubt called the Queen's redoubt, and the remainder at the " Bluff," overhanging the Maori landing place on the river Waikato where they were employed in constructing a stockade.

In July by desire of the Lieut. General, at the request of the Governor, the Commanding Royal Engineer, made a design for a block of buildings, arranged so as to be defensible, which were intended to be erected at a place called Kohe-kohe on the left bank of the Waikato, about 8 miles higher than the " Bluff." The project grew out of a plan for building a court house, to be used also for the meeting of the "Runanga" or native council of the district, and there was to be, in addition, accommodation for a native police.

Large quantities of timber were cut and prepared for the work, and delivered in the early part of 1863 on the site, when the King* natives took the alarm, (having probably got some impression that something more than a court house was intended), came down the river in considerable numbers, well armed, removed the whole of the timber and stacked it carefully ashore near the " Bluff."

This matter of the court house was supposed to be one of the causes which induced the natives to assume the hostile attitude which eventually led the Governor to move the troops to the European frontier at the Waikato as here-

* By the term *King* natives, is meant, those in rebellion who were attached to the party of the Maori King.

after recorded, and thus to anticipate the natives in their threatened irruption into the settled districts.

It was a matter of complaint by the natives against the early missionaries, that whilst the latter were directing the attention of their hearers to heaven they were moving the earth from under their feet; alluding to the fact that the missionaries had misused their influence over the then simple natives to acquire large quantities of land from them. Probably they similarly thought at the present time that the Governor's new institutions would have a similar effect, and that they would eventually find that their cherished lands had insensibly eluded their grasp.

At the end of October, 1862, a body of troops were sent to continue the Great South Road, from the point at which it was suspended, to the Maungatawhiri Creek. The new portion of the road which was $3\frac{3}{20}$ miles in length, though it involved heavy works, was executed more economically than the first portion, costing only £1,651 per mile. This economy was due to the almost universal adoption of a system of piecework.

In the month of January, 1863, the Governor went up the Waikato as far as Ngaruawahia, the ordinary place of residence of the Maori King, quite unexpected by the natives, and had an interview with the leading chiefs, including William Thompson, who anxiously desired to draw from the Governor a recognition of the Maori king, but the Governor evaded the subject and turned the conversation, adroitly eliciting from the natives their objects and desires, particularly in reference to the block of land in the Taranaki Province named Tartaraimaka.

This block was an outlying district, about 11 miles south of New Plymouth, with native land intervening between it and the main part of the settlement. During the course of hostilities in the year 1860, it became necessary to abandon the block. The natives then occupied it, erected several pahs upon it, and thereafter, according to Maori customs and ideas, considered it theirs by right of conquest.

In the early part of March, 1863, the Governor proceeded to Taranaki to resume occupation of Tartaraimaka, and on the 4th April a force of about 400 men under the immediate orders of the Lieut. General, who was accompanied by the Governor, proceeded from New Plymouth, and re-occupied the block, on which a redoubt for the accommodation of 200 men was erected.

On the 4th May, the first overt act of the natives in the renewal of the war was committed at a place called Wairau, near the Oakura river, on the southern road, when a body of about 40 natives waylaid a party of two officers and a small escort, proceeding from Tartaraimaka to New Plymouth, killing the two officers and seven of the men, one man only escaping to convey the intelligence.

After the murder, which however was considered by the natives as only an ordinary act of war, those engaged in it, with a numerous body of others, retired to a spot called Kaitake, a strong position on the lower ranges of Mount Egmont, which they had for some time past been fortifying. They also occu-

pied ground on the south side of the Katikara river, the southern boundary of Tartaraimaka, and constructed certain defences thereon.

Hitherto no native land had been occupied by the troops, but it now became necessary to establish posts intermediate between New Plymouth and Tartaraimaka to protect the communication with the latter and to hold Kaitake in check.

On the 13th May, the Waitara block, the acquisition of which was the original cause of the war that commenced in 1860, was evacuated by the troops by order from the Governor, who had issued a proclamation renouncing all claim to the same on the part of the Government.

Without passing any comment on the political aspect of the question, it is most deeply to be lamented that so much blood had been shed, and so much treasure wasted on a questionable transaction.

On the evening of the 3rd June, the Lieut. General moved from New Plymouth southwards with a force of 400 infantry and 3 guns, which was increased to a total of about 800 men by detachments from the several posts, including Tartaraimaka. A position was taken up at daybreak on the 4th June, on the north side of the Katikara river, and the guns, aided by the fire from H.M.'s ship Eclipse, off the coast, cannonaded the enemy's position on the south side of the river. The infantry crossed the river under cover of this fire, which then ceased, and the position was assaulted and carried against an obstinate resistance of some of the natives in the principal work. The casualities in this affair were one man killed and ten wounded, of whom two died of their wounds. The bodies of 24 of the natives were found and interred.

The winter having now completely set in, the weather being exceedingly wet, and the roads being in some places almost impracticable, rendering the supply of the troops at Tartaraimaka and other posts exceedingly difficult, these posts were evacuated. The natives once more obtained possession of the block, and in a triumphant boastful manner circulated a report that, "The Pakeha (foreigners) fled from Tartaraimaka one very windy day—they all escaped." This anecdote is amusing and is very illustrative of one of the features of the Maori character.

To return to affairs in the Auckland province. In the early part of June rumours were rife that the Waikato natives contemplated a raid into the province even up to the city of Auckland. There is no doubt that the Maoris were in an excited state, were collecting and arming, but were held back by some of the leading chiefs, especially William Thompson, and they hesitated to strike the first blow. They had been alarmed by an expression, attributed to the Governor that, "He would not cut down the flag (metaphorically expressing the Maori King) but would dig round it till it fell," and they believed that the Kohe-kohe court house was one of his mines towards this object; they certainly baffled him in a very characteristic way in that project, still they were distrustful of him, likening him to a rat burrowing underground, saying that they "did not know where he would come up."

It was doubtless seen by the Governor, that there could be no peace in the

country until the Waikato natives were punished, and hence the campaign hereafter recorded.

With the view of placing the Auckland city and province in the best practicable state of defence, and admit of her Majesty's troops being moved to any district where their services might be required, the militia of the province were called out for actual service; and the government also enlisted, under certain conditions, a body of men to form a regular force, which eventually amounted to nearly 4,000 men, and was divided into four Regiments called, "Waikato" regiments, who were to be located, when their term of service had expired, on lands in the Waikato or other conquered districts.

On the 8th July orders were issued for the removal of every available man from Auckland and Otahuhu to the Queen's redoubt, considerable detachments being posted at Drury (where a depôt for provisions was formed), and at a place called Tuakau, about 7 miles lower down the Waikato than the "Bluff."

A proclamation, addressed to the Waikato chiefs, explaining the Governor's reasons for adopting the measures above mentioned was issued on the 11th July.

Early on the morning of Sunday, 12th July, 350 men proceeded from the Queen's redoubt to the Maungatawhiri creek, which is here the boundary between the European and the Maori lands, crossed it and took up a position on high ground on the farther side.

This was a positive invasion of the Maori country, which the natives had so long been zealously guarding, and the gauntlet being now thrown down by the Governor, the natives were not long in taking it up.

On the 17th July, an additional number of troops was sent to the position beyond the Maungatawhiri, which had the name of Koheroa, and which was being strengthened by redoubts, and just as they reached the ground a body of about 200 Maoris were seen advancing leisurely along the ridges from the southward towards Koheroa. The troops were put in motion towards them, and followed them for nearly two miles, the Maoris retiring very steadily in extended order as the troops advanced. The former commenced a dropping fire from the most advanced of a series of rifle pits that had been previously prepared, which they abandoned as the troops advanced, but having reached one of their most carefully formed and extended line of pits, they opened a very heavy fire, which being returned for a few minutes, the troops advanced to the charge led by the Lieut. General. The Maoris retired precipitately down gullies and through a thick bush, overhanging the river Whangamarino in their rear where they had left their canoes, in which many of them got away by brisk paddling. The loss of the enemy was 20 known to be killed. The casualties amongst the troops were one man mortally, and 11 others, wounded, including Lieut. Colonel Austen, 2nd Batt. 14th Regiment.

On the same day (17th July), a return convoy, under an escort of 50 men, proceeding to Drury from the Queen's Redoubt, was briskly attacked close to a bush by a considerable body of Maoris, who inflicted a loss upon the party of 4 men killed and 10 wounded. The loss of the enemy was supposed to have been slight, one body only being found.

On the 16th July, under orders from the Governor, the Chief Ihaka (Isaac) was taken prisoner near Drury, it having been ascertained that he was mixed up with the Kohe-kohe affair, though he was in the receipt of a salary from the Government, shewing how little dependence could be placed on the great majority of the so called friendly natives.

The bush on the Great South Road between Drury and the Queen's Redoubt, being evidently occupied by predatory parties of Maoris, as shewn by the attack upon the convoy, and by the murder of four persons, one a woman, and another a young boy, who were peaceably employed in farming operations near Drury, 5 posts were established on the line of road, garrisoned each by 100 men, who sent out patrolling parties during the day, especially about the times of the passage of the convoys.

About this time the Maoris were assembling in considerable numbers at Rangiriri, a small village about 20 miles up the Waikato from the "Bluff." Very few natives actually resided there, but it was considered by them a place of importance, as they held councils there occasionally. They now commenced the construction of works which will be hereafter described. The information was obtained from a Mr. Armitage, who lived a few miles up the river from Rangiriri, on property belonging to his wife, a Maori woman. This gentleman was subsequently murdered by the natives, whilst employed in the Queen's service.

Arrangements were now made to establish a line of posts from Papakura, near Drury, along the Wairoa Road to the sea, and also from Papakura to the sea at Howick. These posts were principally garrisoned by the local forces. By the establishment of these posts the main part of the frontier line referred to in the paper A in the Appendix, was guarded.

It may be here mentioned that a small steam vessel called the "Avon" had been purchased by the Colonial Government, had been protected by musket-proof iron plating, and was brought into the Waikato and up to the "Bluff." Nothing larger than a Maori canoe had ever navigated the waters of the Waikato before, and this vessel thus became the pioneer to carry civilization into the very heart of the Maori country.

In the early part of August, the natives who had been assembling at Rangiriri, moved down to a place called Mere-mere, on the right bank of the Waikato, and commenced the formation of extensive works about a mile South of the Whangamarino; and in the middle of the month the Lieutenant General ordered the establishment of a post on the high ground on the north bank of the Whangamarino near the scene of the affair of the 17th July. The Maori works at Mere-mere commanded the only land access to their position, which was through a swamp almost entirely covered at the time with water.

Shortly subsequent to the attack of the convoy, on the Great South Road, arrangements were made for cutting down the bush for a width of about 200 yards on each side of the road, so that the enemy might not be able to surprise or attack the troops, passing along it, with so much facility.

On the 25th August, a party of soldiers 25 in number thus employed were

surprised by a body of natives, who captured 23 stand of rifles belonging to the party, killing two of the men. This attack was the most enterprising affair that the natives had undertaken. The bush was doubtless full of their scouts, who had probably observed, during several days, that the arms were piled and almost unprotected, and hence resolved upon the attempt for their capture. Subsequently covering parties were stationed along the road.

A substantial bridge was now constructed over the Maungatawhiri, and a causeway across the swamp on the other side was commenced so as to give more ready access to the Koheroa position.

On the 7th Sept., the natives murdered Mr. Armitage (before mentioned) and two Europeans who were with him, attacked and burnt a pah belonging to friendly natives, at Cameron town, a village on the right bank of the Waikato, three miles below Tuakau, destroying a considerable quantity of commissariat supplies stored there for transit up the river; and lastly attacked a party of the 65th regiment, under Captain Swift, which had proceeded from the Tuakau redoubt to the succour of the friendly natives. Captain Swift and two men were killed, the subaltern and two men severely wounded, and one man was missing. The small party, reduced finally to 28 men, behaved most gallantly, under the command of Sergeant McKenna, who was eventually commissioned in the regiment and decorated with the Victoria Cross.

Several attacks were made in the early part of September, on the posts on the Great South Road, and on stockades occupied by Militia in the bush on the west of the road, the natives on all occasions being beaten off, but not without loss on the part of the defenders. These several attacks, shewing considerable enterprise and activity on the part of the natives, were presumed to have been made by detachments from Mere-mere, where they were for the present unattackable for want of sufficient water conveyance.

For a month there was not any apparent movement on the part of the natives, but on the 23rd of October the Militia, who had moved out from their stockade at Mauku to drive away what was presumed to be a small party of Maoris removing cattle belonging to the settlers, found themselves almost surrounded by an overpowering force, before which, after a gallant resistance, they were obliged to retire, having suffered a loss of 2 officers and 6 men killed, and some wounded. It is presumed the natives lost heavily, for they retired from the ground immediately, thus enabling the Militia to bring in their killed and wounded.

About the time of the re-commencement of hostilities in May, the Colonial Government ordered an iron steamer to be constructed. This vessel, which was fitted with 2 gun cupolas, was, after much delay, brought into the Waikato, and arrived at the "Bluff" on the 27th of October, bringing with her, in tow, 4 boats, each of 10 tons, which had been iron-plated and each fitted to mount a 12-pounder gun.

On the 29th of October the Lieutenant General reconnoitred the enemy's position at Mere-mere firing a few shells into it. The fire was returned by the

enemy from three guns, which they had mounted near the bank of the river in carefully formed embrasures well traversed between.

On the 30th, the Lieutenant General, accompanied by all the officers commanding corps, went up the river to near Rangiriri, reconnoitring the right bank; on returning, orders were given for the embarkation in the two steamers and the four gunboats of 600 men of all arms, who left the "Bluff" at about midnight, receiving a sharp fire on passing Mere-mere; and at day-break of the 31st, the troops were landed at a place about 10 miles from the "Bluff," and about 7 miles from Mere-mere in rear of the enemy.

A position was taken up on rising ground and was immediately commenced to be strengthened by earthworks. The Lieut. General returned in the evening, to the Queen's redoubt leaving Colonel Mould, Royal Engineers, in command, with instructions to hold the position until further orders, and to complete the entrenchments.

Shortly after midnight (31st Oct.—1st Nov.,) the camp was vigorously attacked by the natives who were supposed to have been detached from Mere-mere to observe the movements of the flotilla. These natives when beaten off are presumed to have returned to Mere-mere to report the landing of the force, for soon after day-break on the 1st Nov., the enemy were discovered on the move up the river Whangamarino having evacuated the position which they had occupied for three months, and on which they had bestowed an immense amount of labour.

The Maoris at once saw that they were out-manœuvred and like good strategists, retired from a position where they were liable to be attacked in rear whilst engaged in meeting an attack on one flank.

Instructions were sent on the 4th Nov., to the officer commanding the up river force to reconnoitre Rangiriri, and if many natives were seen in its vicinity, he was ordered to remain in his position, where he would be re-inforced; if otherwise he was to return to head-quarters at the Queen's redoubt.

No natives being seen the force returned by land *via* Mere-mere, which had been occupied immediately on the retirement of the enemy and which was being entrenched.

The rebels, continuing hovering in considerable numbers in the bush about Paparata and between that and the Wairoa valley, it was determined to establish a line of posts between the estuary of the Thames and the Queen's redoubt. Accordingly, an expedition proceeded by sea from Auckland, in the middle of November, landed near Pukorokoro, and erected a redoubt for 120 men at that place. The redoubt being completed and garrisoned, the remainder of the force moved on and erected two other redoubts in suitable positions where they could be seen from the Queen's redoubt.

Early on the 19th Nov., 300 infantry embarked on board the "Pioneer" and "Avon," which each took in tow two of the gun-boats, whilst the Lieut. General with 3 guns and about 1,000 infantry marched, *via* Mere-mere, towards Rangiriri, distant about 13 miles. The troops were halted about 600 yards from the

enemy's works, (Plan No. 3) which had been extended and made formidable, and preparations were made to assault them. The three guns were placed in the centre with the greatest part of a regiment in reserve near them. 100 men of this regiment (the 65th) were formed on the right as the column of assault, to which were attached 75 men under the direction of an officer of Royal Engineers carrying scaling ladders and planks, to assist in getting across the ditch. Detachments of other regiments were placed on the left to be moved forward in skirmishing order to keep down the enemy's fire.

The Infantry in the steamers were to land in the rear of the line of works to cut off the retreat of the enemy, both operations being covered by the fire of the field guns and of those in the gun boats. Owing, however to the unwieldiness of the "Pioneer" she could not be readily brought alongside the bank, and as the day was well advanced, the Lieutenant General decided not to wait and the field guns opened fire. Shortly after, the assaulting party advanced with great spirit, and entered the main line of works to the left of their centre with little difficulty, but with rather heavy loss, and throwing the right shoulder forward cleared the ground in rear, and captured a line of works parallel to the river, being eventually brought to a stand by a sort of redoubt of rather imposing profile in the centre of the line on the highest ground. Three several assaults were made on this redoubt but all failed of success, the enemy evincing the utmost spirit, and inflicting many casualties on the assailants.

An attempt was then made to mine the work, and a gallery was run in; but unfortunately the fuse, which had been provided with other Engineer Stores, had been mislaid on board the "Pioneer," and the operation was necessarily abandoned. Recourse was then had to the pick and shovel to bring down the parapet, and considerable progress was made with a breach, when about midnight the work was ordered to be suspended. The breach was re-commenced at day-break of the 20th and was nearly practicable, and a second on the rear face of the redoubt was well forward, when about 5 a.m. the enemy, in number 183, came out of their works displaying a white flag.

The Lieutenant General complimented them on their bravery and they were then ordered to lay down their arms, an order which was evidently totally unexpected, and a great hesitation was shewn, but seeing themselves surrounded they threw down their arms in a very sulky manner. These men, who were made prisoners, some ten months afterwards escaped from the place where they were located.

It was conjectured that the number of the enemy in the works when attacked was about 400, of whom 39 at least were killed, as their bodies were found; this number, added to 183, the number of prisoners, making a total of 222, would leave about 170 as having escaped during the night. Amongst those who escaped were the Maori King and William Thompson, the latter of whom was seen shortly after the surrender advancing with about 200 followers, with the intention it was understood, of relieving their countrymen; but when they found from a half caste interpreter who was sent to them, that their people were

prisoners, they turned back; Thompson, however, sent to the General a whalebone "Mere" in acknowledgment, it was presumed, that they were beaten.

The loss in the capture of the position was very severe, amounting to two officers and thirty-seven men killed, and thirteen officers and seventy-six men wounded; of the wounded four officers and four men subsequently died of their wounds.

Rangiriri being captured it was determined to hold it, and to form there an advanced depôt for supplies, for the protection of which the necessary entrenchments were constructed.

The troops, with the exception of 150 infantry and the Royal Artillery, moved from Rangiriri on the 2nd of December up the right bank of the river, and in three marches reached a place called Rahuipokeka, opposite which lay the "Pioneer"; she had with much difficulty made her way up the river between the numerous shoals, which, however, at this point became less obstructive.

On the morning of the 8th of December the Lieutenant General went up the river in the "Pioneer" to reconnoitre Ngaruawahia the ordinary residence of the Maori King, where the "Runanga" were held, and where the King's flag was flying. The place being found to be evacuated, the Lieutenant General returned to Rahuipokeka, embarked 500 men and again went up to Ngaruawahia, landing the troops, who encamped about the King's house, (Whare). The Queen's flag was immediately hoisted on the King's flagstaff,* thus even according to the Maori ideas their capital was lost. The defences of Ngaruawahia consisted of a line of rifle pits and a small redoubt which had been constructed with a view to oppose a landing. Such opposition would doubtless have been made, had not various reasons, some political, intervened, and induced them to evacuate the place without a struggle. They took the precaution when leaving, to remove the bones of Potatou, the first Maori King, from the tomb in which they had been deposited.

About this time it was ascertained that the natives had established themselves in strong positions at two places on the roads or tracks leading from the Waipa river to Te Awamutu and Rangiawhia, their most important settlements in the Waikato district. These positions are hereafter referred to.

Towards the end of December an expedition composed of the 50th regiment, and some militia, proceeded by sea to Raglan (Wangaroa) on the West Coast to occupy that place, as the right of the proposed new frontier line, which was to extend from Raglan to Tauranga in the Bay of Plenty on the east coast. It was hoped that the occupation of Raglan would facilitate the operation of transmitting supplies to the Waikato District, but unfortunately it was found that the track from thence passed over so difficult and wooded a mountain range that it was scarcely practicable even for pack horses, though a great deal of labour had been expended on it.

A forward move was made with a force of about 1,200 men on the 28th

* The flagstaff in the metaphorical language of the Maoris was called "Father of Waikato."

December, to Whata Whata, one of the places of residence of the friendly Chief William Naylor (Wiremu Neira), some of whose people attached themselves to the force, and were subsequently employed in conveying mails and despatches. A large stockade was here constructed to cover an advanced depôt of provisions. A farther move was made on the 1st January, 1864, to Tuhikaramea, a short distance up the Waipa, from Whata Whata, where the force remained until the 27th January, to admit of Whata Whata being well stocked with supplies. On the above day, the troops moved, and in two marches, reached Te Rore, having traversed a difficult country, and passing on their left, at about a mile distant, the enemy's position of Pico-pico, one of those before referred to. In these two days' march it was necessary to construct six rough timber bridges, to enable the guns and provision carts to cross the more difficult streams; thus, these marches, though short in distance, were long in point of time. After passing Pico-pico, a portion of the force was detached to proceed down the river's bank, whilst the main body went on to Te Rore. The detached body halted at Ngahinapouri, where a strong redoubt was erected on the right bank for 200 men, and another on the left bank, immediately opposite, for 100 men. This position was occupied for the protection of the river communication.

At Te Rore there were extensive fenced clearances and large orchards, which had surrounded a house belonging to a European settler, in right of his wife, a Maori woman; but the house had been burnt by the enemy some few days previous to the arrival of the troops.

As Te Rore was the highest place up the river Waipa to which the steamer "Avon" could attain, the formation there of a large depôt of stores and provisions was determined on, and three redoubts, two on the right bank, and one on the left bank, were constructed to secure the position, which was less than three miles from each of the two Maori positions, Pico-pico and Paterangi. A redoubt for an outlying picket was also thrown up, about three-quarters of a mile from the camp, in view of Paterangi. On the 4th February, a part of the force at Te Rore moved up and occupied a ridge, about 1,500 yards from Paterangi, on the summit of which, a breastwork was thrown up.

The force was detained at Te Rore in consequence of an accident which happened to the "Avon" steamer, which struck upon a snag in the Waipa, knocking a hole in her bottom and she sunk with a large quantity of provisions (nearly ten days supply) on board.

This unfortunate occurrence not only delayed operations, but doubtless instilled a great amount of confidence into the enemy at Paterangi, seeing, as they did, a large force in their immediate vicinity in apparently an inactive state, and they were thus probably encouraged to make the attack below detailed. The occurrence entailed a great amount of labour on the Royal Engineers, who, with the aid of working parties from the Line, had to bridge numerous creeks and clear tracks through thick bushes on the left bank of the river Waipa in order that carts might bring up provisions by land. Indeed, throughout the campaign, the pick, shovel, and felling axe were in incessant requisition to construct in-

trenchments, and to open communications for the force through this difficult country.

The men of the force in front of Paterangi were in the habit of going down to the river Mangapiko, about 600 yards distant, to bathe and wash their clothes, under cover of an armed party. This being observed by the natives, they laid an ambush on the 11th February, amongst the high fern on the further side of the river, and fired upon the bathers. An additional armed party was immediately sent down, and a sharp skirmish ensued, resulting in the defeat of the enemy, with a loss of 24 killed, besides 4 prisoners, two of whom were dangerously wounded. One of these died, and the other, a mere boy, was sent back to the enemy, as he was pining after the death of his comrade.

To prevent similar attacks in future, the Lieutenant General decided on having a redoubt, for 200 men, erected near the scene of the skirmish of the 11th, and it was placed in a position near an extraordinary curve in the Mangapiko river, where there were the remains of an old pah, called Waiari, having high banks and excessively deep ditches. A road to allow of the passage of carts was formed through this pah, and a bridge constructed over the river, to admit of easy communication with the redoubt.

Sufficient supplies having been accumulated at Te Rore, the force moved on the night of the 20th February from the main camp, the troops in front of Paterangi being left in position.

Tents were not struck until after dark, in order that the enemy, whose scouts were constantly on the watch, might be kept in ignorance of the movement as long as possible.

The force, consisting of about 1,200 men including cavalry, moved without guns or baggage viâ Waiari by a cattle track towards Te Awamutu, which was reached on the 21st, about $5\frac{1}{2}$ a.m., where the whole of the Church Mission buildings were found intact, though it was anticipated they would have been destroyed by the enemy. A few men were halted at Te Awamutu, the rest proceeding on to Rangiawhia, where a skirmish took place resulting in ten or twelve of the enemy being killed, and the capture of several prisoners. The first shot was fired by a Maori woman from a bush, from which she emerged shortly afterwards with a broken arm, and the blood streaming therefrom. She had over her shoulders a blanket like a man, and could not have been taken for a woman, partly hidden as she was in the bush. This incident shows what was ascertained in many instances, that the women are as eager to fight as the men, and have as much spirit and determination. Some of the natives held the "whares" (native houses) most tenaciously, continuing to fire through interstices in the walls of one of them after it was set on fire, and until the roof fell in upon them. Three charred bodies were subsequently found in the ruins. Lieutenant Colonel Nixon, commanding the Colonial Cavalry, received on this occasion a wound in the chest, from which, after months of severe suffering, he died.

The troops at the conclusion of this affair returned to Te Awamutu, where head-quarters were established.

The natives at Paterangi got early intelligence that they were out-flanked, and soon after noon they arrived at Rangiawhia, took up a position on the side of the village towards Te Awamutu, and commenced to convert an old bank into an intrenched line. Their proceedings being observed by an advanced piquet and reported to head quarters, the force moved out to attack them, and after a smart skirmish they were driven from their intrenchments and through Rangiawhia, from which they retired with the utmost precipitation, leaving behind them pots full of pork boiling, and potatoes peeled in readiness for a great feast. Seventeen bodies were picked up after the skirmish, and others on two or three successive days, in the bush and fern. Two men killed and seven wounded were the casualties on the side of the troops.

The account sent of this affair by the Maoris to their friends at a distance is rather amusing, and illustrative of their untruthful character. They said that the horse soldiers first came at them, and with one volley they stretched them all "on the bed of death;" that the foot soldiers then advanced, and with another volley they stretched them also "on the bed of death." Thus, having killed all the soldiers, there was no use in remaining at Rangiawhia, and they went to Maungatautari to build a Pah there. A similar instance of their untruthfulness was mentioned by a gentleman, formerly in the service, who was a guide to an officer of Royal Engineers on a reconnoissance in the Waikato district and towards Raglan, in 1861. At the latter place they met William Naylor, the friendly chief, and the conversation turning upon the Taranaki war, the latter asked how many soldiers were killed there; the reply being "About 60," * he said, in short terms, it was untrue—that they (the natives) knew there were 2,000. As they are so untruthful themselves, the natives believe the Europeans are equally so.

The Lieut. General commanding determined, after the last mentioned affair, to hold Rangiawhia, and it was occupied by about 600 men, with 2 guns, and a redoubt was constructed on a prominent point, near the centre of the village; another post was also established in an old pah called Haerini, near the scene of the skirmish, which was subsequently improved into a good redoubt for a detachment of 50 men.

Kihi-kihi, one of the places of residence of Rewi, the great chief of Ngatimaniapoto, is about 3 miles distant by the road from Te Awamutu, and as it was not impossible that, after his retirement from Paterangi, he might take up a position there, the place was reconnoitred by a strong force on the 23rd, and on the 27th it was occupied by about 600 men, and a redoubt was erected on commanding ground in the village.

The soil about Rangiawhia and Kihi-kihi was very rich and fertile, and had been, in former times, before the King movement commenced and the Maoris had turned their attention to politics, very extensively cultivated, growing large quantities of wheat and maize; even latterly there was a considerable quantity of produce raised in the vicinity; and though potatoes had been sent to the enemy at Paterangi and elsewhere, in large quantities, yet a large amount re-

* The actual number was 66 including Militia.

mained, which made a most acceptable addition to the sol ough this difficult growing maize, of which there was a large area, afforded food to the draught bullocks, thus diminishing the dema transport of which was a serious item in the expenditure. ıbit of going down

The devotion to politics of the Maoris spread all through t wash their clothes, and on the march the neglected state of what evidently h e natives, they laid vated districts, was very apparent. the further side of

The vicinity of Whata Whata was especially rich; hen party was imme- signifies "garner of garners" descriptive of the prolific natu the defeat of the

Plans Nos 4 & 5. The Maori works at Paterangi and Pico-pico, whom were dan- were destroyed, a redoubt being erected on par oy, was sent back former, it occupying a commanding position on the route fr ıeral decided on Awamutu.

At Taranaki, the local government had about this time coll skirmish of the military settlers; and the force in the province amounting to ab e in the Man- including 1,000 regular troops and some militia, it was determin Vaiari, having the outposts on both sides, north and south, of New Plymouth. passage of posts that had been abandoned were re-occupied, and some others es river, to —one in particular on the north of the town, on Sentry Hill, a command point, on which a redoubt for 100 men was constructed.

The natives, on their side, occupied three positions, including Te Arei, to the northward; and two, including Kaitake, to the southward. They frequently issued from these positions to lay ambuscades, and to drive off or wantonly destroy cattle. On the 28th February a party from Kaitake murdered a settler within four miles of New Plymouth; it was therefore determined, if practicable, to root out these troublesome hornets from their nest; and the operations for the purpose are recorded in the regular sequence of events in the North Island.

Te Awamutu being a little in rear of the centre of the proposed new frontier line between the Horatiu branch of the Waikato and the Waipa, it was made the head-quarters of a separate command, which included also the troops at Rangiawhia, Kihi-kihi, Te Rore, and Ngahinapouri. Preparations were made to hut the troops, and five redoubts were thrown up round the large Mission House, the head-quarters. Close to the Mission House was a well-built timber church, with a conspicuous spire which had been erected from funds contributed, in great part, by the natives of the district, who also furnished some of the labour.

The Lieutenant General with a force of 900 men left Te Awamutu on the 22nd March, *en route* to the Horatiu, passing on the road an abandoned Pah at Ohaupo, which had been constructed by the Maoris in case of the line of advance to Te Awamutu being by the Horatiu; thus with Pico-pico, Paterangi and Ohaupo, they considered they had blocked up all the practicable avenues to their two richest settlements in the district between the two rivers.

The force halted and encamped at the village of Pukerimu, about 6 miles distant from the termination, on the left bank of the Horatiu, of a branch of

the Maungatautari ranges, where at a spot almost overhanging the river called Pukekura, the enemy had constructed an imposing work, and a second smaller one about 400 yards distant higher up the range, from which the lower work would have been commanded. The position was reconnoitred, and preparations were made by the manufacture of gabions, &c., to attack it in form. At the same time redoubts for 200 men each were constructed on each bank of the river at Pukerimu. Whilst these works were in progress the officer commanding at Te Awamutu having received information that the enemy was constructing a Pah at Orakau, about seven miles from Te Awamutu and four miles from Kihi-kihi, put three columns in motion very early in the morning of the 30th March, to move on different routes towards the Pah, so as to surround it. This operation was successfully accomplished by daylight, and an assault was immediately made on the work, which failed, the officer leading falling mortally wounded. A second assault also failed, the enemy defending their post most resolutely.

Plan No. 7.

Plan No. 6.

The officer commanding then determined to sap up to the pah, and gabions having been prepared, the sap was commenced on the afternoon of the 31st March, and carried on with great enterprise and activity, until the morning of the 2nd April, when the Lieut. General arrived from Pukerimu, accompanied by the Commanding Royal Engineer, who took charge of the work. A double sap was broken out from the single sap and carried to the ditch of a sort of outwork* which was then assaulted and captured. Cover was obtained in two of the ditches of this work, and gabions were rapidly placed and filled on the edge of the ditch of the south face, when the enemy suddenly evacuated the mainwork, broke through the cordon of troops, and fled to the southward. They were pursued as rapidly as the embarrassing nature of the ground would admit, losing a great many in their retreat. Their whole loss, as ascertained, was 101 killed, and 23 prisoners, of whom 21 were more or less severely wounded.

The determination of these people was shewn by their answer to the summons of the General to surrender, "We will fight for ever, for ever, for ever." ("Ake, Ake, Ake.") When urged to send away their women, of whom unfortunately, there were several killed and wounded, they replied, "The women will fight too." The losses of the troops in the attack were heavy, and were sustained principally in the first assaults on the Pah; they amounted to 16 killed and 52 wounded.

Lieut. Hurst, 1st batt., 12th Regiment, Assistant Engineer, carried on the Engineer operations with great spirit and intelligence, and was especially mentioned in despatches, and the detachment of Royal Engineers under his command were commended in a General Order of the Corps.

The day after the fall of Orakau, the Lieut. General returned to Pukerimu. During a reconnoissance of the position at Pukekura on the 5th April, it was found that it was evacuated, and possession was taken of the work. There is little doubt that the intelligence of the heavy losses the Maoris had sustained at Orakau had reached Pukekura, and caused the abandonment of the position.

* This outwork was incomplete.

Strong redoubts were immediately commenced on the sites of the two Maori works, that on the lower for 200 men, and on the upper for 50 men.

On the 16th April, the Lieut. General left Pukerimu with the intention of proceeding with re-inforcements to Taranaki, where an unfortunate affair had recently occurred.

Before relating this, the operation of the capture of Kaitake must be recorded.

On the 25th March a force of 420 regular troops and militia, accompanied by 3 guns and a howitzer, moved from New Plymouth to near Kaitake. The guns were placed in position about 1,500 yards from the right of the enemy's rifle pits, and made such accurate practice that most of the enemy were driven out of those portions of the works.

In the meantime, a party of 80 military settlers, who had left their redoubt about 1 a m., and, with immense labour, had worked a track to the base of the spur on which the rifle-pits rested, arrived. The difficulty of this advance may be judged when it took 9 hours to accomplish $2\frac{1}{2}$ miles. At $10\frac{1}{2}$ a.m. the guns ceased firing; the main body of the troops advanced to within 800 yards of the works, whilst the military settlers ascended the spur, and carried in succession the rifle pits and upper Pahs, pouring a reverse fire into the trenches behind a lower line of palisading, which the enemy held until a portion of the main body had ascended a rise on their extreme left; when both flanks being turned, they retreated through the bush in their rear. A redoubt for 100 men was immediately commenced on the site of the uppermost Pah. The enemy's works were gradually destroyed, the bush in the vicinity cut down, and a practicable road made to the position.

Notwithstanding every precaution, four days after the capture of the position, the enemy laid an ambuscade within 150 yards of the redoubt, and caused two casualties—one man killed and one wounded. This affair, and the unfortunate one previously alluded to, which took place on the 6th April, shewed either that the natives were not dispirited by their reverses, or else wished to have "utu"—satisfaction. On the above date, a party of 100 regular troops and militia, under the command of Capt. Lloyd, 57th Regt., was sent to reconnoitre a track between Kaitake and Ahu-ahu. Arrived at the latter place, whilst engaged in destroying cultivations, they were surprised by a strong body of natives, who poured in a volley, which brought down Capt. Lloyd and several men, and rushing on, scattered the troops in all directions. They escaped by various routes, carrying with them some of the wounded, and reached a neighbouring redoubt near the sea coast, from whence a large party was marched to the scene of the attack, where they recovered the bodies of Capt. Lloyd and six men, which had been much mutilated, and some of them, including that of Captain Lloyd, decapitated.

Not long after this affair, the gross superstition called "Pai-marire," with which the natives had been embued, was first heard of; and it was stated that the head of Captain Lloyd, after being prepared in some way to preserve it, was carried about in procession by the fanatics, who made numerous proselytes in every part of the country, part of the initiation being to drink of water which had been poured over this preserved head.

The disciples of this superstition were called "Hau-hau," from their making use, in their ceremonies, of these words, which sound something like the barking of a dog.

On the arrival of the Lieutenant-General in Auckland from Pukerimu, intelligence was received of the threatening aspect of affairs at Tauranga, which had been occupied by troops some three months previously, the natives of the district having erected a work a little more than two miles from the military post at Te Papa.

Accordingly, the proposed movement to Taranaki was postponed, and reinforcements were re-despatched to Tauranga, whither the Lieutenant-General also proceeded.

Plan No 8.

The enemy's position, when reconnoitred, was found to consist of a well-traversed trench cut across a narrow part of the long promontory, near the east end of which the Mission Station of Te Papa and the military post were situated, the two ends resting on swamps, and having in the centre two works—sort of redoubts—in which there were several intricate and covered passages; the whole line, inclusive of the redoubts, was palisaded. It being determined to attack the position, during the 27th and 28th April, the guns and mortars noted in the margin were disembarked, and during the night of the latter day put in position, low breastworks having been thrown up to give a little shelter to the gunners. Late in the evening of the 28th, 650 Infantry moved at low water over the mud flats of the harbour, well clear of the enemy's right, and took up ground about half a mile in the rear.

Naval Guns.
1 110-pr. Armstrong.
1 40 do.
—
Rl. Artillery.
2 8-in. mortars
2 24-pr howitzers.
5 Coehorn mortars.
2 6-pr. Armstgs.

Soon after daybreak on the 29th, fire was opened from the guns and mortars, and continued for about eight hours, by which time a breach had been made in the main work, and the palisades in front of it destroyed; a storming-party, of 300 men, one half of which was composed of seamen and marines, then moved forward in two columns to the assault.

The stormers had no sooner entered—which was accomplished without much difficulty—than they were encountered in the most determined manner by the Maoris; and after a few minutes' obstinate conflict, in many cases hand to hand, the men retired from the redoubt under a heavy fire. This assault cost the force, both Navy and Army, many most gallant and excellent officers and men, the casualties amounting to 7 officers killed, 3 mortally wounded, and 25 N. C. officers and men killed and mortally wounded. Those otherwise wounded were 4 officers and 72 N. C. officers and men. The troops in the rear, about the time of the assault, closed in upon the work and engaged some of the enemy who were attempting to escape; but notwithstanding their vigilance, during the night after the assault the Maoris succeeded in creeping away to the rear, taking with them some of their wounded. Twenty killed and six wounded of the Maoris were found in the redoubt in the morning.

Panics such as that which seized the men of the assaulting party are not easily accounted for at any time, but in this particular case it may not unfairly

be assumed that the nature of the defences, with the peculiarities of which the whole of the storming-party were unacquainted, led to the unfortunate result. The troops were actually in possession of the upper part of the redoubt, but the underground passages were still held by the Maoris, and the men became distracted at seeing their comrades fall by the fire of an unseen enemy whom they could not dislodge.

The courage and endurance of a small body of Maoris exposed to an almost crushing artillery fire for a period of eight hours, and then at its termination meeting and repelling a gallantly conducted assault, are almost unequalled; and show that whether acting amongst the swamps and bush of their country, or in a scarcely tenable earthwork in an open country, they are a foe not to be despised. They possess the highest military qualities: coolness, wariness, spirit, determination; judgment in taking up positions; sagacity in perceiving the moment when to vacate them; and they are never depressed by reverses. The Lieutenant-General, in his despatch of the 4th April, in reference to the attack on the Orakau Pah, pays a tribute to the heroic courage and devotion of the band of natives who held that position. An individual instance may be given. After the pah was evacuated, the bodies of the slain Maoris were brought out for the purpose of identification by the interpreters attached to the force. The body of a man of considerable stature had on it two mortal wounds through the head, but, in addition, both bones of the left leg were fractured, and were rudely bound up with a sort of splint; and the shinbone of the right leg was also at least splintered; thus this man, though undoubtedly suffering great agony from the wounds in his lower limbs, must have continued to fight until he received his mortal wounds.

The Lieutenant-General left Tauranga for Auckland on the 16th May, after giving instructions for the erection of huts for 500 men, the future garrison of Te Papa.

Not long after the arrival of the troops at Tauranga, a detachment was sent to Maketu, a place about twelve miles to the eastward on the coast, where a redoubt was erected and garrisoned by regular troops and militia, 120 in all. This post was established with the view of keeping the King natives in that direction in check, and also as a *point d'appui* for the Arawas, friendly natives inhabiting the district. The enemy sat themselves down before the redoubt, erected Pahs against it, and menaced a serious attack, which they commenced on the morning of the 27th April; however, by this time, the Arawas had assembled, and being reinforced by some militia, and aided by the fire from one of H.M.'s steamers and a colonial gunboat, which arrived in the morning off the coast, they assaulted the Pahs, driving the enemy in disorder from them, and following them in their retreat along the coast until nightfall. On the following morning they came up with the enemy strongly posted at a place called Te Awa-o-te-Atua; after a sharp skirmish they dislodged them, the enemy retreating rapidly into the difficult country in the interior. In these operations, the enemy lost between 80 and 90 killed, whilst the Native Contingent lost only one chief and six other men. The officer in command of the

Native Contingent was Major Drummond Hay, Auckland Militia, formerly an officer in the Royal Artillery.

In the Province of Taranaki, to which it is necessary now to return, there was on the 30th April a very severe lesson administered to the rebels, who, to the number of about 300, assembled in the bush near the Sentry Hill redoubt, and made a spirited attack on it. The officer in command ordered the garrison to sit down on the banquette until the natives were very close, when they rose and delivered such a close, rapid fire, that the enemy were driven off, with a loss of 34 killed and numbers wounded, who were carried off by their comrades. The only casualty in the garrison was one man wounded.

The Lieutenant-General, on his arrival in Auckland, was instructed by the Governor to send additional troops to Wanganui, which was in imminent danger of being attacked; and also to Napier, where a larger force was urgently demanded by the local authorities. Accordingly, 300 men were ordered to each place. Previous to the arrival of the reinforcement at Wanganui, a party of rebel natives, in attempting to descend the river to attack the town, were met and defeated with great loss by a body of friendly natives. The safety of the settlement was thus for the time secured.

The officer left in command at Tauranga, in making a reconnoissance into the interior of the district, came on the 21st June upon a body of about 600 natives who were entrenching themselves between six and seven miles from Te Papa. Dispositions were made to attack them, and reinforcements were sent for. In the meantime a brisk fire was kept up on both sides for nearly two hours, when the troops advanced and carried the works most gallantly against a desperate but short defence, the Maoris retreating through difficult ground, leaving 107 dead, besides 27 wounded men and 10 prisoners. The casualties amongst the troops were 9 rank and file killed, 6 officers, and 33 non-commissioned officers and men wounded.

This affair had very important consequences, for at a subsequent date, 5th August, a party of chiefs came into Te Papa, and made their submission in presence of the Governor and the Lieutenant General, and moreover ceded to the Crown a considerable district of country round Tauranga. The Governor, however, following a principle which had been laid down in respect to confiscated lands, returned a considerable portion of this land for the location of these submissive natives, and moreover promised them a supply of seeds to replace what had been destroyed during the operations of the war.

It may now be mentioned that the prisoners taken at Rangiriri and elsewhere, were confined on board a hulk in Auckland harbour, but as there were several deaths from dysentery, and as there was a probability of this and other diseases increasing, arising from depression of mind in confinement acting on bodies more or less debilitated by privation exposure and other hardships, it was arranged they should be removed to an island called Kawau, the property of the Governor, about 30 miles from Auckland, where they might be located on shore, and lead a more active life. A large portion of the island was placed at their disposal for cultiv tion; they had commenced to prepare the ground

for seed, and were apparently contented with their position; but during the night, about the middle of September, they suddenly departed, having, it is presumed, been aided by their friends on the main land, which was only three or four miles distant.

They took up a position on the summit of a hill which they fortified, managed to obtain arms, and held a defiant tone. They subsequently left this place, and it was fully understood that many of them rejoined the rebels.

There was at this time a lull in warlike operations, but the mass of the troops in the colony (the north island) were posted in important strategic positions in readiness to meet any hostile movement of the enemy.

The first warlike movement took place in Taranaki. The officer commanding that district having received information that Mataitawa had been evacuated by William King's natives, he determined to attack it whilst it was weakly defended. Accordingly he assembled a force near Sentry Hill on the 8th of October, and first attacked Manutahi, which was feebly defended, captured it, and pushed on to Mataitawa, which was reached and occupied without opposition. The works at Manutahi, which were formidable, as well as those at Mataitawa, were destroyed.

On the 11th October, a force was sent to capture Te Arei, which was effected without firing a shot. The Engineers immediately commenced the construction of a redoubt on this very commanding position. A few days later troops were posted at Manutahi and Mataitawa, and redoubts for their protection were erected at both places, and the bush round them and between the two posts was cut down.

The officer commanding, considering it advisable to extend his positions, now re-occupied Tartaraimaka, which had been abandoned, as before recorded, in June.

On the 17th December the Governor issued a very important proclamation.

During the same month, under instructions from the Governor, the force at Wanganui was very materially increased: the object of concentrating this force being to take military possession of a block of land called Waitotara, the native title of which had been extinguished, but of which the Maoris kept defiant possession, and had erected works thereon in a difficult position.

Towards the middle of January, 1865, the Lieutenant General with additional troops left Auckland for Wanganui. After reconnoitring, he ordered the construction of redoubts on commanding positions round the town of Wanganui, to cover it from the incursions of the rebels. On the 24th of January a column of 800 Infantry with two guns moved towards the Waitotara, and halted near the small village Nukumaru, about 2½ miles from the rebels' position, and they had scarcely arrived when one of the pickets was fiercely assailed by the Maoris, who kept up a heavy fire until late in the night, causing the death of 4 persons, one of them a staff officer. On the following day, about noon, both the pickets which had been thrown out, and were each 100 strong, were briskly attacked by two bodies of Maoris, amounting together to 600 men, who drove in the pickets with loss and advanced towards the camp, being checked only

by the advance of additional troops. This attack was the most daring the natives had attempted during the war, and it was attributed to the fanatical spirit with which they were inspired by the "Pai Marire" superstition, the believers in which were told by their prophets that they were proof against the bullets of the "Pakeha." They put the more faith in this, inasmuch as (as subsequently ascertained) not one of them was hit on the previous night. They were rudely undeceived on this day, as they had upwards of 70 casualties in all. The affair cost the troops a loss of 13 killed, and 2 officers and 24 men wounded.

The force, which had been augmented to the number of 2,300 of all arms, remained at Nukumaru until the 2nd February, when the Lieutenant-General moved at night with about half the force to the Waitotara, which was crossed early on the morning of the 3rd on a cask raft, which had been constructed by the Engineers; and the troops encamped on level ground on the farther or right bank There was a precipitous bluff on the left bank of the river, on which a redoubt for 150 men was immediately commenced, which was, when completed, armed with two guns.

The force moved on the night of the 15th February from the Waitotara to the Patea, being replaced at the former place by the troops which had been left at Nukumaru on the 2nd.

A halt was made until the 24th February on the left bank of the Patea, during which time a redoubt for 200 men was being erected; the main body then crossed to the right bank, where an intrenched line, with a redoubt in the centre, was constructed, enclosing a large area, where buildings for a great depôt of supplies were thereafter erected, as well as huts for 600 men.

On the 28th February the Governor landed at the Patea to confer with the Lieutenant-General in reference to future operations, and it was arranged that an advance should be made along the coast towards Taranaki as far as the nature of the country and the advance of the season would admit, if practicable, as far as New Plymouth. This measure, his Excellency considered, would have a greater moral effect on the natives than even the capture of the strong Pah on the Waitotara block.

About this time there was a conflict up the river Wanganui between the friendly natives and the rebels under a chief named Pehi, in which the latter were defeated. Pehi, who had taken the oath of allegiance to the Queen, and afterwards joined the rebels, asked reinforcements from Te Ua, the leading "Pai-Marire" prophet, who was living in the Wereroa (Waitotara) Pah, but which he was unable to send, and recommended Pehi to make peace. He was also inclined for peace himself, and originated a correspondence, which, however, did not result in any arrangement.

Orders were issued for a move from the Patea on the morning of the 10th March, but during the previous night a fierce gale, accompanied with torrents of rain, arose, which levelled four-fifths of the tents, tearing some to shreds, thus preventing the intended move; nevertheless, the troops who had been left at Waitotara came on to Patea, according to orders, encountering great diffi-

culties in wading through streams swollen by the rain, in which many rifles were unavoidably lost.

The force at length marched on the 13th March, under the orders of the Lieutenant-General. At about two miles from the camp the column was assailed by a volley of musketry from a body of Maoris posted under cover of a ridge of sand-hills, parallel to the line of march on the right. The advanced guard were thrown out in skirmishing order, bringing round their left flank to attack the enemy, who were soon dislodged, retreating through swamps and difficult ground, nevertheless losing 23 killed and mortally wounded, and two prisoners; whilst the casualties amongst the troops were only one man killed and three wounded. This affair, in which 100 natives attempted to check the movement of upwards of 1,000 troops, exemplifies still more their courage and daring, doubtless augmented by the new superstition.

The force moved on and encamped in a Maori village called Kakaramea, in which was immediately commenced a redoubt for 150 men who were to occupy the position, which was about seven miles inland near the margin of the bush, and close to the right bank of the Patea river.

The following day the column moved, and encamped at the Maori village Manutahi, which was about four miles from the coast and from the village of Manawapu, the latter being, at one period, a place of considerable importance. Detachments were sent to this village, which was situated on the left bank of the river Ingape, and as it seemed practicable to beach boats on the sandy shore on the farther side of the river, redoubts were constructed on both banks to cover a depôt of stores which it was proposed to form under their protection.

The force with head-quarters moved from Manutahi on the 29th March, halted for one day a few miles from Manawapu, and on the 31st proceeded to the Wai-ngo-ngo-ro (Snoring river), where a camp was formed, and redoubts were erected on both banks of the river. It was thought possible that a landing might be effected at the mouth of this river, and hence the necessity for establishing these posts to protect the operations of bringing ashore and protecting the supplies.

On one of the occasional reconnoisances which were made from Waingongoro, to feel for the enemy, shots were fired upon the troops from a stockaded village, which was entered without opposition, the few natives in it having decamped. A flagstaff, surrounded with a neat wooden railing, shewing it was "tapu"—sacred to the new religion—was ordered to be cut down, but not any further damage was allowed to be done, and the troops retired.

A small steamer which had been hovering off the coast for some days, seeking an opportunity to land, managed, on the 8th April, to send a boat on shore with some provisions; but on the 10th a boat was upset in the surf, three of the boatmen were drowned, and others much injured. A similar but more disastrous accident occurred at Manawapu on the 3rd April, when six men lost their lives.

These accidents, exemplifying the difficulty of feeding the troops by sea on this inhospitable coast, and the land route from Waingongoro towards Taranaki being known to be less and less practicable, finally determined the Lieutenant-

General to retrace his steps. Accordingly, the force marched to the rear, leaving 150 men in each of the redoubts on the two sides of the river.

The Lieutenant-General left the Patea on the 29th April, to proceed to Auckland to confer with the Governor as to the future measures he wished to be adopted.

In the month of April the officer commanding in Taranaki still further extended his outposts. On the north, about 35 miles from New Plymouth, a post was established at the "White Cliffs." The only direct track that existed between the Taranaki country and the north by which the Waikato rebels used to travel, passes at the base of these cliffs. Thus, if this track was closed, the only other route was a very circuitous one inland, stated to be upwards of 100 miles longer. On the south of New Plymouth a post was formed at Warea, about 27 miles from the town; and another at Opunake, 23 miles still farther south. Thus about 85 miles of coast was occupied by numerous posts, from which, however, it was scarcely possible to move out of gunshot without danger.

The force in the Wanganui District amounted to about 2,000 men, under the command of a brigadier, whose head-quarters were in the town; and there was a body of about 750 men at Patea, who were to undertake such operations as might be called for during the winter months.

Under instructions from the Lieutenant-General, the Brigadier proceeded to Nukumaru for the purpose of constructing redoubts to contain 200 men. The object of establishing this post was that a constant watch might be kept on the natives in the Wereroa Pah, who would thus be kept in a continual state of suspense and anxiety, having a very wearing effect on the savage mind, which cannot endure a continuous strain upon it; and a further object was that it might be used as a base of operations if the Pah was attacked.

It was further ordered that, if practicable, a small force should proceed from Wai-gno-gnoro to meet a corresponding body coming from Opunake, which was about 22 miles distant from the former place. A junction was effected on the 8th June; thus nominally, and only nominally, opening the coast road from New Plymouth to Wanganui, which had been barred to Europeans since the commencement of the Taranaki war in 1860. The difficulties met with on the march by these two bodies, which were in the lightest possible order, were almost insurmountable.

Plan No 9.

In the early part of July, negociations were being carried on between the agents of the Colonial Government and the natives in the Wereroa Pah for its surrender; and a small body of the colonial forces of both races was encamped near it. About the middle of the month the Governor arrived and communicated with the rebels, who were on the point of surrendering, when they saw some of the regular troops from Nukumaru near at hand, and they ordered his Excellency off. A native orderly of the Governor, who had a perfect knowledge of all the intricacies of the district, was appointed to guide a body of the colonial forces by a circuitous and very difficult track to a point on the right rear of the Pah, from which it could be commanded within musket shot. Early on the morning of the 22nd July this party opened fire on the Pah, and a demonstration was made against it in front, when a white flag was

hoisted, and some friendly natives went into the Pah, of which the only tenants were a blind man and an old woman, the rest of the occupants having slunk away. A detachment of Her Majesty's troops was located in the Pah, on the site of which a strong redoubt was erected.

Matters remained tolerably quiet during the latter part of August and in September, except in Taranaki, where occasional skirmishes took place, without much result, except losses of men, on both sides. Towards the end of the latter month a proclamation was issued by the Governor declaring that the war which commenced at Oakura in May, 1863, was at an end. Copies of this proclamation were largely distributed by means of the friendly natives, but it had not the least effect in quieting the rebels.

During October several very spirited affairs took place about the Bay of Plenty and Poverty Bay between the colonial forces, aided by friendly natives, and the rebel natives who had adopted the new superstition, in the attempt to capture those who had murdered an estimable missionary, the Rev. Mr. Volckner, and Mr. Falloon, an agent of the Colonial Government.

One of the friendly natives employed in the distribution of the peace proclamation, was invited by the rebels near Wereroa Pah to bring them a copy; on approaching them he was treacherously fired upon and mortally wounded, the rebels thus showing their contempt for the document. A reward of £1,000 was offered for the capture of any one of the three natives who were known to the messenger, and named in his dying declaration. Not long afterwards, a Mr. Broughton, attached to the troops as interpreter, went by invitation to confer with the rebels in another direction in reference to their submission, and he also was treacherously murdered.

Subsequent to these murders, officers in command of posts and districts, whose hands had been tied by the peace proclamation, were ordered to retaliate upon the enemy.

Towards the end of this year (1865) a military commission was convened for the trial of certain of the murderers of the Rev. Mr. Volckner, and 16 were convicted and sentenced to death; but as this commission was illegally constituted, these prisoners, with some others connected with other murders, were tried before the Supreme Court, where 29 in all were convicted, of whom 5 were sentenced to death and executed.

At the end of December, 1865, Major General Chute, who had succeeded to the command in the Australian colonies on the departure of Sir Duncan Cameron, K.C.B., proceeded to Wanganui, and in the beginning of 1866, headed a force of about 400 men, to which was added a body of the local forces, European and Maori, and marched inland, attacking and destroying two strongly fortified Pahs about six miles from the Patea camp. The Pahs were but feebly defended, the rebels retreating into the bush on an assault being threatened.

Later in the month (January) the strong Pah Otapawa was attacked, captured and destroyed. This place was defended with considerable vigour, and the troops sustained rather a heavy loss, 11 persons including Lieut. Colonel Hassard, 57th Regiment, having been killed or mortally wounded, and 11 others wounded.

Subsequent to this affair several other Pahs, strong by position and art, were captured, and destroyed, the enemy evacuating them previously to the arrival of the troops, in consequence, it was presumed, of the lesson they had received at Otapawa.

In accordance with the desire of the Governor, the Major General moved on the 17th January, with a force of about 400 men from the vicinity of Waingongoro, into the bush by a Maori tract at the back or east of Mount Egmont, with the view of following it to Mataitawa in Taranaki. This movement, it was considered would have a good moral effect on the natives, who made use of this tract in going to and from the Taranaki and Wanganui districts, it being much shorter than the coast track. It was presumed that the march might be effected in three days, hence provisions for only that number of days were taken. However, it was found that the distance was much greater than was calculated upon, being 54 miles, and the difficulties encountered so great, there being no less than 111 streams and deep gullies to be passed, that it took eight days to accomplish the distance, though the troops were on foot for ten hours each day, subsisting for two days on horse-flesh, the rest of the time on reduced rations and some biscuit which had been sent by a party from Mataitawa to meet them.

The force returned to the Wanganui district through New Plymouth, and by the coast roads, halting for a day at Opunake, where was found amongst other natives located in the vicinity, Te Ua, the prophet, and founder of the "Pai-Marire" fanaticism, who was sent to Wellington for the disposal of the Governor.

Between the beginning of January and the 6th February, this force had captured and destroyed 7 fortified Pahs, and 21 open villages, with the cultivations attached to them.

Opinions in the colony were very much divided as to the effect upon the natives of the operations above described. Certain it is, that the natives about the town of Wanganui became more active and enterprising, and it was found necessary to re-garrison the redoubts covering the town, which had been evacuated by the troops.

Further, nearly 200 natives, living near Opunake, who had always been neutral, went over in a body to the enemy. The destruction of property was understood to have been under the advice of the Colonial Government, but it is believed to have been mistaken policy; the natives invariably retaliated, and destroyed property of the settlers a hundred times more valuable than that which they themselves lost.

The operations last described terminated real offensive war on the part of the Queen's troops in the colony.

By the end of March, 1866, four out of the ten regiments had left the colony, and three others, with the two batteries of Royal Artillery, were being gradually drawn towards Auckland, for embarkation, leaving three regiments, which were to garrison the Australian colonies, including New South Wales, Queensland, Victoria, Tasmania, and New Zealand. One complete regiment was, as a temporary arrangement, to remain in New Zealand, but all the outposts were to be withdrawn, and the two towns of Auckland and Wanganui were alone to be garrisoned.

T. R. M.

APPENDIX A.

Memorandum in reference to the occupation of the Waikato Country.

Taking it for granted that the aboriginal natives in the Waikato Country will decline the terms of submission and restitution offered to them by the Governor, it is a matter for the most serious consideration what measures shall be adopted to carry out His Excellency's views to effect a complete present pac fication in the colony, and to guarantee future quiet and obedience to the Queen and the law.

The character of the natives, the nature of the country they occupy, the vicinage of some of the most warlike of their tribes to the European settlements, the scattered localities of the out-settlers in the several districts of the Northern Island, the value of the property, especially in flocks and herds, of the out-settlers, which is at the mercy of the Maoris, should all be taken into consideration in the adoption of measures having the above object in view. The question is really more political than military, though it can only be successfully solved by military aid.

It is believed that if the initiative is taken by an armed force advancing with a hostile attitude into the interior of the country with the object of attacking the natives in their settlements, the whole race, with the exception of the principal part of the great Ngapuhi tribe to the north of Auckland, will immediately rise in arms, will attack, probably murder, the out-settlers, sweep away or destroy their sheep and cattle, and burn or level their homesteads to th e ground, and no vigilance nor any reasonable force that could be sent with the view of protecting the settlements could by any possibility save them from this fate.

The principal towns of the settlements, Napier, Wellington, and Wanganui, might indeed be tolerably secure under the rifles of the troops in garrison, and the out-settlers who left their districts in time might take refuge therein and secure their persons, but their property would be gone, and the best half of the colony pauperised.

The above being the probable loss to the colony by the initiation of hostile measures, it may be considered whether there would be any compensating gains by the adoption of such measures.

Supposing a column in force, overpowering as regards the numbers that the natives could bring to oppose it, were to advance into the heart of the country, say to Ngaruawahia as the first objective point, it may be, without doubt, predicted that the enemy would be found to have evacuated it; the place is nothing, it is the location for a few miserable " whares," a mere place of temporary meeting, for some of the Waikato tribes; in fact, through the whole of the immense district in the central part of the Island, there are not any large locations. The enemy would abandon all their small villages on the approach of the troops, sending out small parties in every direction to effect the destruction of the out settlements, to harass the troops, when encountering the difficulties of a march into their wild country, to attack convoys and escorts and to interrupt commu-

nications, but no where would they be met in force, and the campaign would be barren of results, a mere following through an almost impracticable country of an ever retreating enemy, who would move from one flank to another, in any direction, and lead a force far beyond its depôts, from whence it must derive its means of subsistence. A second, even a third campaign might be carried on in this way, all equally devoid of effective results; the enemy might indeed be brought, eventually, by the absence of the means on which they ordinarily subsist, to a sullen temporary acquiescence in the power of Her Majesty's arms, or rather to an acknowledgement of the superior perseverance and determination of the European, but at what a cost of treasure, and life, on both sides would this result be obtained? The savage would become still more savage, less likely to come under the influence of a humanizing civilization, would probably still offer a passive and sulky resistance to the introduction amongst them of just laws, and possibly look forward to a time when by the withdrawal of troops they may again have hopes of successfully asserting their independence and recovering their position.

There is not any gain apparent in the picture above pourtrayed; it is certainly possible that the land which the natives hold so tenaciously might be confiscated as a compensation to the colony for the loss of property, but if the colonists are pauperised where is the money to proceed from to purchase this land? What strangers would come into the country to settle in the vicinity of armed savages? and what is to compensate the loss of life, military and civil? and how is the imperial government to recover the sacrifices it will have made in support of the colonists? but above all how is the land so confiscated to be held? it can only be by the strong armed hand involving for many years the maintenance of a large military force in the colony and heavy disbursements on the part both of the imperial and local governments.

If, then, there is to be much loss and no gain by carrying on active hostilities, is there any other course by the adoption of which it is possible the natives may be induced to acquiesce in the terms proffered for their acceptance? Amongst these terms are the recognition by the natives of the sovereignty of the Queen, and the right of making roads and communications through their country. The sovereignty of the Queen, or as termed by them, "the shadow of the Queen over the land," it is not likely they will dispute, though still insisting upon their right to have a king or head of their own; but the right of making roads they will doubtless refuse peremptorily. They have invariably resisted urgent entreaties to permit roads to be made through their lands, under a declared belief that they, the lands, would, by the fact of the construction of those roads, pass from them. Under this declared belief there probably lurks a desire to keep their country inaccessible to the onward march of the colonists. They do not refuse permission to Europeans to pass along the native tracks, but they require them to avoid certain "tapued" places, and to make difficult circuits and traverses of the main rivers; and that permission they may at any time, and capriciously, revoke, and seal the entrance to their country.

independent people like the Maoris—that sovereignty implies a right of freely traversing the country over which that sovereignty extends: a right of traversing involves the right of making such communications as will facilitate free and uninterrupted movement to any part of that country. It is undoubtedly just that the lands required for the formation of such communications should be acquired by equitable purchase or negotiation; but failing the acquisition by such modes, and in face of a possible avowed determination to resist this, one of the prerogatives of sovereignty, and especially as in the case of the Maoris they owe a debt to the Europeans for attacking them and destroying their property without cause, it would not be really an aggressive measure to take lands from the natives for the formation of roads, but rather a "material guarantee" to afford the means of obtaining future security; and it is possible, seeing that the natives always desire that their adversaries should strike the first blow, that no armed resistance may be offered, and that the Maoris will be wise and far-seeing enough to discern that they cannot effectually resist the onward roll of civilisation.

Looking to this possibility, by which the objects in view may most probably be effectually attained, and looking on the other hand to the almost certainty that if the natives are attacked they will revenge themselves on the unprotected persons and property of the out-settlers, it would seem to be a wise course to adopt the measures which will be most likely to save money, lives, and time, in tranquilising the country.

There is no surer index to the true civilization of a country than good roads, and the formation of them in an uncivilised country has, from the earliest ages, been the means by which a savage, barbarous, or independent people have been brought into subjection, or redeemed from a state of lawlessness. The traces of the great Roman roads in Britain, made 1,200 years ago, are still to be seen; that civilised and warlike people well knew that they could not effectually subdue and keep under control the savage and brave Britons, without ways pervading the country and penetrating its recesses, by which they might convey their legions, stores, and war engines. In later years the Highlanders of Scotland could never be prevented from rising in insurrection until great roads were made through their mountainous district. The savages of North America are only quelled by pushing roads through the almost interminable forest, and establishing military posts on the frontier, and there is an incessant warfare going on, with varying success on both sides, but with the eventual subjugation of the different tribes. During the last war at the Cape of Good Hope, the only error committed by Sir Harry Smith, according to the dictum of the Duke of Wellington in his place in the House of Lords, was an omission in making great military roads into the Caffre's country. Can such precedents be safely or wisely set aside? Is there anything in the nature of this country or the character of its aboriginal inhabitants that can make a rule of conduct so general, inapplicable? On the contrary, it would appear especially applicable to the wilds and difficulties of the country in New Zealand, to the nature of which the Maoris adapt their mode of warfare.

Having thus arrived at a conclusion that it would be infinitely less costly in blood and treasure, and a saving in time in effecting the pacification and civilization of the country, to commence the construction of good roads and bridges, and gradually carry them forward by and under the protection of a military force, than to make a hostile move, (bearing also in mind that some sort of track or communication must necessarily be made into the heart of the country, or to any objective points of attack in order to render an advance practicable) it may be considered what preliminaries should be arranged, and what precautions ought to be taken to secure the City and District of Auckland from possible molestation.

The preliminaries would necessarily be political. The Maoris having declined to accede to the terms proposed, having evaded or ambiguously replied to them, or having passed them over in contemptuous silence, the Governor might, at a suitable season of the year, issue a proclamation stating his intention of making the Queen's sovereignty pervade the land by the exercise of her right of making roads through it, that the roads would be made under the protection of the Queen's troops, and that any resistance to this measure on the part of the Maoris would be an opposition to the Queen and a cause of war.

Previous to commencing operations on the roads a good defensible frontier should be decided upon, and posts of sufficient strength established to cover the district and out-settlers of Auckland. The line that appears the best is that which commences near the mouth of the Waikato river, running eastward to Maungatawhiri (Havelock) where the Waikato bends sharply to the southward, thence northwards by the Great South Road to Papakura, and from thence eastward by the Wairoa Road and the Wairoa River to the sea.

A post should be established near the village of Waiuku as near the Waikato as possible, to guard the "portage" by the Awaroa River from the Waikato to the Waiuku Creek on the Manukau, and a second near Tuakau. The centre of the line would be at Havelock, where large depôts of stores and provisions may be formed within a fort or large redoubt having a sufficient number of men for their protection. On or near the line of the Great South Road between Havelock and Drury small bodies of men posted in stockades, at moderate intervals, would be necessary to guard and keep open the communication, especially through the great bush. At Drury other depôts would be required for the reception of stores and provisions sent forwards water-borne by Slippery Creek, and a sufficient guard for their protection, who may be posted in a stockade, already constructed, near which the store buildings may be constructed. The stockade at Papakura occupied by cavalry would watch the junction of the Wairoa Road with the Great South Road, and from thence by the Wairoa Road to Thorpe's homestead on the Wairoa River. Cavalry patrols would be the most effectual means of guarding the frontier and preventing any ill-disposed natives from penetrating within the line. A stockaded cavalry picquet-house, with sheds for horses, may be established near the "Traveller's Rest" hotel on the Wairoa Road, where the head-quarters of the cavalry may be stationed. Thorpe's homestead is near to that part of the

Wairoa River, where it ceases to be fordable, and there a stockade for 100 infantry, the force being in part composed of the volunteers of the district, may be erected. The extreme left of the line at the mouth of the Wairoa River might be most efficiently guarded by the naval forces, and a stockade might be erected there, with a boat-house attached, to be garrisoned by seamen. A vigilant watch kept up by the garrison of this post, with guard-boats sent out occasionally at night, would effectually prevent war-canoes passing along the coast or up the river. The rear of the right of the line near the Waiuku Creek may be further strengthened by posting there a well-manned gun-boat.

These several posts being established in such order as may be most convenient, the road from Drury to Havelock may be improved, and those portions which are simple tracks widened, formed, and made as practicable as possible; so also should the road to the Wairoa be ameliorated and the bridges repaired, in which work it is presumed that the Provincial Government would aid.

All these works would be on European land, and ought not to arouse the jealousy, still less the hostility of the natives.

Beyond Havelock the country belongs to the natives, and the largest possible force, after sufficiently providing for the security of the city and district, should be thrown in advance to cover the formation of a main road on the right bank of the Waikato River towards the interior of the country. The advance from this point must be cautious, and may be deliberate, not effected by mere tracks made with haste to indicate an intention to attack, but by roads as well and substantially formed as the nature of the country and the means at hand will admit, evidencing a determined purpose of carrying them through the country.

The officer commanding the advance should be cool, wary, and discreet, avoiding collision with the natives and keeping his men well in hand, under strict surveillance, bearing in mind that a single first shot fired on his part, may be the means of lighting a flame through the whole land and jeopardising half a million's worth of property. This caution being observed it is probable that the formation of the roads would not be opposed by the Maoris, who would succomb to an inevitable necessity, and by judicious reasoning might be brought to recognize the value to themselves of this civilizing proceeding.

If the natives peaceably acquiesce in the formation of roads, it would indicate an acknowledgment of the Queen's sovereignty, and the abandonment of their King; thus two of the most important points (upon which the others may be really considered to hinge) in the terms offered to these people, will have been gained by a little forbearance, and at a comparatively small cost.

It would seem just that land acquired under the influence of the power of Her Majesty's arms, and secured by the labour of her troops, should be retained by and disposed of by the imperial government as a part compensation for the sacrifices the English public will have made on behalf of the colony.

THOMAS R. MOULD,
Colonel Commanding Royal Engineer.

24th June, 1861.

PAPER IV.

SCREEN BATTERIES.*

Reasons for adoption.

The great penetration and large bursting charges of the shells fired from the rifled guns now in use, render it necessary to give the parapet of a battery exposed to them a minimum thickness of 25 feet, and to place the guns farther apart (viz., 36 feet from centre to centre) to prevent the possibility of a single shell bursting in a merlon, filling up two embrasures, and thus silencing the fire of two guns.

The great number of shells which will be used in future, and the greater accuracy with which they will be projected, render it advisable that each gun in a battery exposed to such a fire, should be separated from the next gun by a substantial traverse.

The above requirements render the execution of an elevated battery, likely to be exposed to the fire of heavy rifled artillery, a work of such very great labour, that in future operations such batteries will be very rarely, if ever, thrown up; batteries will therefore be sunk as much as possible to obtain the necessary cover. As in future attacks the guns used will be 40 prs., 64 prs., or some such guns, whose range is perfectly effective up to 2,000 yards, greater opportunities will be afforded for the selection of sites, and it is therefore hardly possible to conceive any case (except on rocky or marshy ground), where it would not be feasible to select sites for batteries, in which the guns might be sunk so much as to admit of the natural ground forming the soles of the embrasures.

The more frequent employment of shells fired horizontally, and the extreme accuracy with which they can be thrown by rifled artillery, render it probable that in sieges of places armed with such guns, the building of a battery by day, or even by night, if its position be known, will be almost impossible, or will, at all events be attended with great loss of life and time. All attempts to throw up and arm a battery, with the necessary requirements, between dusk and daylight, have been unsuccessful, but it has been found possible to complete and open fire from one, in which the terreplein is well sunk into the ground, by daybreak on the second morning; but in order to prevent the work being inter-

* Extracted, by permission, from the new Battery Book now being compiled at the Royal Engineer Establishment.

rupted after daybreak on the first morning, it becomes necessary to conceal the position of the battery from the enemy. The range of the guns in the new siege trains being now extended to 2,000 yards, it will probably be generally possible to select sites on which batteries, during their construction, will also be concealed from the enemy's view by features pre-existing on the ground itself, such as close fences, shrubberies, woods, embankments, standing corn, &c.; where such natural screens, however, do not exist, recourse must be had to artificial screens.

General description.

The battery, that has therefore been adopted to meet the whole of the above considerations, is one in which the terreplein is sunk so much, that the ground forms the soles of the embrasures, and the construction of which can be concealed by an artificial screen, until it is ready to open fire at daybreak on the second night, or 32 hours after its commencement.

The screen itself, besides concealing the battery while being erected, will be found a useful addition to the minimum thickness of 25 feet adopted for the parapet; it will also cause the explosion of many shells which would otherwise lodge in the parapet of the battery, doing it much injury; practically it has been found that the screen renders it very difficult for the opposing artillery to judge their distance, and strike the battery.

The Screen or Covering Trench

It would not evidently be of any use to throw up a screen or covering trench, only exactly in front of the position to be occupied by a battery, for then the enemy would have a shrewd suspicion of its object; the covering trench must therefore extend along the front of the whole line of intended batteries. The most favourable position for it in front of each battery, is as nearly as possible parallel to, and 59 feet (but not nearer) from its crest, provided that tracing it thus, does not lead the enemy to detect the positions of the proposed batteries.

In order that the screen or covering trench may fulfil its object well, the portion of it lying between the proposed battery, and any part of the enemy's works, must, at daylight on the first night, be as high as possible, and it therefore becomes necessary to revet the interior slope of such portion; the portion that does not conceal the battery need not be revetted.

Details of Working Parties.

The section of the screen or covering trench at the end of the first relief will always be 4 feet deep in front, and 4 ft. 3 in. in rear; the only difference between the portion that screens the battery, and the remainder, being, that the former is revetted, while the latter is not. (Figs. 1 & 2, plate I.)

The best revetment is made, either of gabions of the ordinary size placed on a fascine, or of Jones' iron band gabions made with two or more additional bands, for which special pickets will have to be provided.

The area of the section of the ditch is 20⅝ square feet, and the men may have a task of from 4 to 6½ feet along the line, according to the nature of the soil. Care must be taken not to overtask the men employed at the revetted portion of the screen, or the earth thrown out by them may not, perhaps, completely con-

ceal the gabions from the enemy's view by daybreak, which is an important point. The best task for men, in ordinary soil, will be 5 feet along the line at the screen, and 6 feet at the covering trench. These tasks may be reduced by 6 inches, if the soil be difficult, or increased by 6 inches, if the soil be very easy, making a difference either way of $10\frac{5}{16}$ cubic feet. As the working party employed at the unrevetted portion of the screen or covering trench will not have any material to bring up for its revetment, they can assist to bring up the materials required for the revetted portions.

Although the covering trench will be used as a means of communication to the batteries, yet it is not intended for a parallel, and therefore it will be unnecessary to widen it, or to employ men at it, for more than one relief. The men who work in the first relief should be instructed not to throw their earth far to the front, but to keep it as high as possible. On the second night, that portion of the screen which is between the battery and any guns the besieged can bring to bear on it, will be increased in thickness and height, for the purpose of stopping projectiles fired at the battery, and also of rendering it more difficult for the enemy to ascertain the exact range. One row of diggers will be distributed at intervals of five feet along the ditch dug on the previous night; their task will be to widen the ditch 5 feet, making their excavations 4 ft. 3 in. deep towards the front and 4 ft. 6 in. towards the rear, giving $109\frac{3}{8}$ cubic feet of excavation; they will throw their earth on to the screen.

Another row of diggers will be distributed facing the screen, at intervals of 5 feet along a line traced parallel to the cutting line of the inner ditch, and 30 feet in front of it; their task is 5 feet along the line, 5 feet to their rear, 4 feet deep to their front, and 4 ft. 3 in. to their rear, making $103\frac{1}{8}$ cubic feet; they will also slope the scarp, cutting off one foot at the top, which makes the total task $113\frac{1}{8}$ cubic feet; they will throw their earth on to the screen, taking care to leave clear a berm of 5 feet from their original cutting line (Fig 3, Pl. I.)

As the projectiles at the elevation with which they will be fired from the guns in the batteries will, as a general rule, pass clear above the screen, it will not be necessary to make openings in the screen for their passage. Small openings, however, will be required for laying the gun, so that the line of sight may be clear from the gun to the object to be fired at. In order to determine the depth of openings required, ascertain the height of the eye above the sole of the embrasure of the battery, when the object to be aimed at can just be seen above the screen, and deduct therefrom the height of the line of sight of the gun above the sill; the difference will be the amount the screen must be cut down, in order to allow the guns to be aimed; this can be determined during the first day. In Fig 4 Pl. I. *a d* is the height of the eye above the sill of the embrasure when the object to be aimed at can just be seen over the screen at *b*; *c d* is the height above the sill of the line of sight of the gun; this height being 1 ft. 9 in. for the 40-pdr. and 2 feet for the 64-pdr. when the terreplein is sunk 3 ft. 6 in. below the sill, as in this case. The opening in the screen must be made down to the line *c e f*, which is parallel to *a b*. In ordinary cases the sill of the opening will be on a level with the top of the gabions

of the screen, and the sole will slope about six inches upwards towards the front; the width of the opening being about 3 feet throughout, though of course this depends upon the amount of lateral range required to be given to the guns. Two men will be sufficient to form each opening through the screen on the second night, and as it can be done in a short time, it should not be commenced until the guns are in the battery, and it has been ascertained that all the batteries will be ready to open fire simultaneously. Until required to form the opening, they will be employed shaping the parapet of the screen.

As the covering trench may be thrown up, if more convenient, previously to the commencement of the batteries, and as the length of the revetted and unrevetted portions, and also the length of the portion to be thickened will vary in every case, the estimates of the men, tools, and materials required for its construction have been kept entirely separate from those of the battery itself.

Working parties, &c., for Screen.

The following is an estimate of men, tools, and materials for screen and covering trench in ordinary soil.

Portion of Work.	Men.					Tools.					Materials.		
				Infantry.									
	Officers.	N. C. Officers, R.E.	Sappers.	N. C. Officers.	Privates.	Axes, Pick.	Shovels.	Rods measuring 6 ft.	Mallets.	Tapes, Tracing.	Pickets, Tracing, Bundles.	Gabions	Fascines, 6 feet.
For tracing 1,000 yards of Screen or Covering Trench...	2	2	20	.	...	.	.	...	2	20	1	.	...
For executing 1,000 yards of Covering Trench unrevetted) in addition to the Tracing Party			24	24	600	624	624	24					
For executing 100 yards of revetted screen in addition to the Tracing Party, First Night, First Relief			3	3	60	63	63	3				150	50
For thickening 100 yds of Screen in 2nd Night. Rear Trench			3	3	60	63	63	3		2			
For thickening 100 yds of Screen in 2nd Night. Front Trench			3	3	60	63	63	3					
For each opening in Screen					2	2	2			1			

Detailed description of Battery.

As it is decidedly unadvisable to mass the guns used at a siege in large batteries, the details are given for a screen battery for two guns, which is the smallest number that can conveniently be placed in one battery. Pl. I., Figs. 6, 7 and 8 give the plan and sections of the battery recommended, the general details being as follows: the thickness of parapet is 25 feet, while the epaulments being made 17 feet 6 inches thick, and at right

angles to the crest of the parapet, offer a thickness of nearly 25 feet of earth to all fire coming against them at an angle of 45° with the general direction of the battery.

Each gun space is 15 feet wide by 24 feet to the rear, and is dug out to 3 feet 6 inches deep all over, the parapet being 4 feet high above the ground throughout, thus giving 7 feet 6 inches of cover for the gun detachment.

Each gun is separated from the next by a detached traverse 13 feet thick at the top, raised above the ground 3 feet 9 inches in front and 4 feet in rear, and with slopes all round it having bases of 1 foot. The passages in front and rear of the traverses, and in rear of the epaulments, are dug out to the same depth as the gun spaces, viz., 3 feet 6 inches deep. On the sides of the traverses and epaulments next the guns, berms of 2 feet 3 inches are left forming a very convenient place for "side arms," &c., and giving an increased area for the temporary lodgment of the earth from the gun spaces, previously to its being shovelled forward on to the parapet.

Shell recesses are constructed as follows: before the traverses and epaulments are thrown up, splinter-proof timbers are laid on the ground across the spaces which are to become shell recesses; the traverses and epaulments are then proceeded with, and the shell recesses are afterwards mined out, the splinter proofs already placed, making the roofs of the recesses.

The ditch of the battery and epaulments are dug out to a depth of 5 feet, and the battery is drained into it. By means of the ditch of the epaulment communication is maintained between the battery and the covering trench.

By day-break of the first night, the parapet of the battery must, in order that it may be screened, be levelled off to a height not exceeding $2\frac{1}{2}$ feet above the level of the ground, the epaulments and traverse should be levelled off to 2 feet above the ground, while the magazine, being still further in rear should, if possible, be kept lower; but it must be sufficiently advanced to enable its interior to be completed early on the second night, so that the ammunition may be stowed in it before day-light.

The platforms having to be laid, and the battery armed before day-light on the second night, as much of the excavation in the interior of the battery should be completed the first night, as is compatible with the above mentioned conditions; also the passages in front and rear of the traverses, and in rear of the epaulments, must be excavated to their full depth, to allow of the commencement of the shell recesses at day-break.

The interior slope above the ground line can be revetted with either fascines or sandbags, while the front of the gun spaces, and of the passage in front of the traverse, below the ground line, is best revetted with hurdles or fascines, well secured by pickets tied in to the parapet. The traverse and the rear of the epaulment, above the ground line, can be revetted with either fascines or sandbags, while for the sake of economy of revetting material, all the other slopes below the ground are left unrevetted, with a base of 9 inches to the

height of 3 ft. 6 in., or if that slope be insufficient, at as steep a slope as the soil will allow.

In the plan of the battery given, the front and rear of the traverse, below the ground line, are supposed to be revetted with fascines.

Tracing a screen battery.

The most favourable site for a screen battery for guns would be on the reverse slope of a hill, and the interior tracing line should be as far down it as possible, as at B (Fig. 5, Plate I.) where the works to be fired at can be just seen over the crest of the hill, when the observer's eye is 1 ft. 9 in. or 2 feet from the ground, according as the battery is to be armed with 40 pdrs. or 64 pdrs. Fig. 1, Plate II, is a tracing plan of a screen battery for two guns; the lines traced are shewn in red, and are the perpendicular cutting lines, the slopes being taken off afterwards. The point B having been determined on, and the line of fire A B of one of the guns having been fixed, and marked in carefully with several pickets, the line C D is traced through the point B at right angles to A B, the point C being 10 ft. 6 in. distant from B (viz., 7 ft. 6 in. for the half gun portion, and 3 ft. for the breadth of the berm, and the slope of the epaulment, below the ground line); mark the point D for the centre of the next embrasure, 36 feet from B, and E 10 ft. 6 in. from D. Along D E measure D F 7 ft. 6 in. for the breadth of a half gun portion, and from F at right angles to C D, trace F G 20 ft. 6 in. for the cutting line of the side of the gun portion next the epaulment, and from G, trace G H at right angles to F G 30 ft. 6 in. long, for the thickness of the epaulment with its berms, &c., and from H, H I parallel to G F, 45 feet long, for the exterior cutting line. The other side of the battery will be traced in a precisely similar manner.

The cutting line of the front ditch is traced 37 feet from C E, and parallel to it (viz., 1 foot for the interior slope, 25 feet for the thickness of the parapet, 6 feet for the exterior slope, 4 feet for the berm, and 1 foot for the slope of the scarp of the ditch), also the rounded portions of the epaulments with arcs of 37 feet radius from the points C, E, as centres, cutting the exterior tracing lines of the epaulments in the points K and I. To trace the traverse measure off B L 7 ft. 6 in. along B E, and L M 3 ft. 6 in. long, at right angles to B E. From M trace M N 21 feet long parallel to B E, and from points M and N, trace M P, N O 16 feet long, and join P O.

Trace the base of the reverse slope of the gun spaces parallel to, and 3 ft. 6 in. distant from J H, the tape to be laid from the point Q 5 ft. 6 in. beyond J; at R, 4 feet from the line of fire commence tracing a section 2 feet wide of the ramp, on that side farthest away from the intended magazine, R S 32 feet long and at right angles to Q R (viz., 4 feet for the projection of the tail piece of Clerk's platforms, and 28 feet for the base of the slope, at an inclination $\frac{1}{8}$), and complete the tracing, making S T 2 feet, and T V parallel to R S; make V W 40 feet, and from W trace a section of the ramp for the right hand gun-portion in the same way, and continue the line V W to the point X 5 ft. 6 in. beyond H, the corner of the epaulment, thus completing the tracin .

Tools and materials for tracing. The following tools and materials are required for the tracing:

	R. E. Officers.	Sappers.	Tapes, Tracing.	Pickets, Bundles of.	Level, Field.	Mallets.	6-Feet Rods.
For a screen battery for 2 guns -	1	4	6	2	1	1	1
Extra for each additional gun -			3	1			

1ST NIGHT.

Distribution of working parties. Gun space. The distribution and the tasks of the men at the battery during the first relief, on the first night, are as follows:—In each gun space there are nine diggers; three of them (marked d^1 in Plate II, Fig. I.) are placed along the front at intervals of 5 feet. Their tasks are 5 feet along the line, 6 feet to the rear, and 3 ft. 6 in. deep, making 105 cubic feet each; they throw their earth on to the parapet, keeping it clear of the embrasure. Two rammers work on the parapet in connection with these diggers. The other six diggers (marked d^2 on plan) are placed, three facing the traverse, and three facing the epaulment, at intervals of 6 feet along the lines, commencing from the rear of the portions allotted to the diggers d^1; their tasks are 6 feet along the line, 7 ft. 6 in. to their rear, and 2 ft. 6 in. deep, making $112\frac{1}{2}$ cubic feet for each man; they throw their earth on to the traverse and epaulment respectively, taking care to leave the berm of 3 feet clear. Before these six diggers commence work, they will assist to bring up and place the planks and splinter-proofs for the shell recesses in the traverse and epaulment respectively.

Passage in front of traverse. Four diggers (marked d^3 on plan) are arranged facing to the front, along the cutting line of the front passage, at intervals of 5 ft. 3 in.; their tasks are 5 ft. 3 in. along the line, 3 ft. 6 in. to the rear, and 3 ft. 6 in. deep, making $64\frac{5}{16}$ cubic feet each; these men throw their earth to the front on to the parapet, and from time to time they get on to the traverse, and shovel the earth across from it on to the parapet. The earth on the traverse must not be allowed to accumulate to a greater height than 2 feet. One rammer will work on the parapet in connection with these four diggers.

If the soil be loose, it will be advisable not to keep the earth thrown up near the edge of the cutting, for fear of its weight causing the ground to give way.

Passage in rear of traverse. Three diggers (marked d^4 on plan) are distributed facing to the front along the front cutting line of the rear passage, at intervals of 7 feet. Their tasks are 7 feet along the line, 4 ft. 6 in. to the rear, and 3 ft. 6 in. deep, also the forming of the slope in rear 9 inches wide at top, making a total of $119\frac{1}{16}$ cubic feet; they throw their earth on to the traverse, the flank men taking care to keep their earth clear of the berms. One rammer works on the traverse in connection with these three diggers. Before these

men commence work they will assist to bring up and lay the planks and splinter-proofs for the shell recess in the traverse.

Passage in rear of Epaulment. The length of the passage in rear of each epaulment is 30 ft. 6 in, and four men (marked d^5 on plan) will be distributed along it, facing to the front, at intervals of 7 ft. 6 in. commencing from the end next the gun-space; the 6 inches near the outer ditch, forming the slope of that ditch, being in the task of the digger in that ditch. Their tasks are 7 ft. 6 in. along the line, 3 ft. 6 in. to the rear, and 3 ft. 6 in. deep; also the forming of the rear slope, cutting off 9 inches at the top, making $101\frac{23}{32}$ cubic feet. They throw the earth on to the epaulment.

Two shovellers and two rammers work in connection with these four diggers.

Before these four diggers, two shovellers and two rammers commence work, they will assist to bring up and place the planks and splinter-proofs for the shell recess in the epaulment.

Ramp. A section, 2 feet wide, of each ramp, is excavated on that side furthest away from the magazine. It is dug out to the full depth, 3 ft. 6 in. for the 4 feet nearest the battery, and from that point is sloped up at $\frac{1}{8}$; this task is 126 cubic feet, and is given to one man (d^6); the earth goes to form the magazine between the two ramps, and is thrown clear of the space that will be occupied by the ramp, when it is widened out the next night.

Front ditch of Battery. Fifteen diggers (marked d^7 on plan) are distributed along the ditch facing towards the battery, at intervals of 4 feet; nine of the men occupy the space between the lines of fire, and three are on each flank of the others; their tasks are 4 feet along the line, 5 ft. 6 in. to their rear, 5 feet deep at the cutting line, and 4 ft. 9 in. at their rear, and also to slope the scarp, cutting off 1 foot at the top, which makes their total task $117\frac{1}{4}$ cubic feet; they throw their earth to their own front on to the parapet, taking care to keep the embrasure and a space 5 feet from their cutting line free from earth.

Six shovellers and four rammers will work in connection with these fifteen diggers; it is their duty to form and ram the front portion of the parapet taking particular care that no part of it is more than $2\frac{1}{2}$ feet high.

Ditch round Epaulment. The total length of this ditch, measured along the tracing line from the rear of the passage, in rear of the epaulment, to the ditch excavated by the diggers of the front ditch of the battery, is about 79 feet. Ten diggers (marked d^8 on plan) are distributed along this ditch facing towards the battery: six of the diggers are extended from the rear, the other four are extended from where the diggers of the front ditch of the battery end, all at intervals of 8 feet; their tasks are 8 feet along the line, 5 ft. 6 in. to their rear, and 2 ft. 9 in. deep, making 121 cubic feet; the tenth digger (*i.e.* the last one of the front four) will only have about 7 feet along the line, but being at the shoulder, his total task will be of about the same cubic content as that of the others.

They will throw their earth well to their front, taking care to leave a space of 5 feet from the cutting line clear. Six shovellers and three rammers will work in connection with these ten diggers; their duty is to form and ram the parapet; they must work hard to pass the earth from the shoulder of the epaulment, towards the angle where the interior crest lines meet.

Estimate of Men, Tools, &c., 1st night.

The following table gives the number of men, tools, &c., required for the construction of a screen battery.

	PORTION OF WORK.	MEN.						TOOLS.					MATERIALS.						
													Above Ground if revetted with			Below Ground		Shell Recesses.	
													Fascines.		S.bgs.				
		Marked on Plan.	N.C.O. or Sapper.	Diggers.	Shovellers.	Rammers.	Total Infantry.	Axes, Picks.	Shovels.	Rammers.	Field Levels.	6-ft Rods.	Fascines, 18 ft.	Pickets, Bundles of	Sandbags.	Fascines, 18 ft.	Pickets, Bdls.	Planks, 8 ft.	Splinter Proofs, 9 in. wide.
For a 2-Gun Battery	2 { Gun Spaces, front	d^1	2	6	0	4	10	6	10	4	2	2							
	Do. do. rear	d^2	0	12	0	0	12	12	12	0	0	0							
	1 Passage in front of Traverse	d^3	0	4	0	1	5	4	5	1	0	0							
	1 do. ... do. rear do.	d^4	0	3	0	1	4	3	4	1	0	0							
	2 { Passage in rear of Epaulment	d^5	0	8	4	4	16	8	16	4	0	0	33	8½	736	40	10	20	96
	2 Ramps	d^6	0	2	0	0	2	2	2	0	0	0							
	1 Ditch in front	d^7	1	15	6	4	25	15	25	4	0	1							
	2 Ditches round Epaulment.	d^8	2	20	12	6	38	20	38	6	0	2							
	Total for 2-Gun Battery		5	70	22	20	112	70	112	20	2	5	33	8½	736	40	10	20	96
For each additional Gun.	Gun Space, front	d^1	1	3	0	2	5	3	5	2	1	1							
	Do. do. rear	d^2	0	6	0	0	6	6	6	0	0	0							
	Passage in front of Traverse	d^3	0	4	0	1	5	4	5	1	0	0							
	Do. do. rear do.	d^4	0	3	0	1	4	3	4	1	0	0	19	5	440	20	5	6	32
	Ramp	d^6	0	1	0	0	1	1	1	0	0	0							
	Ditch in front	d^7	1	9	4	2	15	9	15	2	0	1							
	Total for 1 additional Gun.		2	26	4	6	36	26	36	6	1	2	19	5	440	20	5	6	32

Revetters and Tools.	If with Fascines per Battery 2 Guns	8 men	2 mauls	2 handsaws.		
	" " additional Gun	4 "	1 "	1 "		
	" Sandbags per Battery 2 Guns	10 "	4 "	6 axes, pick	6 shovels.	
	" " additional Gun	5 "	2 "	3 "	3 "	

Shell recesses. Before any earth is thrown on to the traverses and epaulments, the splinter proofs which are to support the earth must be arranged; they must be about 8 feet long, with their ends resting on planks $1\frac{1}{2}$ inches thick, laid parallel to the recesses. The scantling of the splinter proofs should be as large as can conveniently be obtained. The length of the planks is immaterial, but 8 feet will be found a convenient length.

The inner row of planks for the shell recess under the epaulment is laid 3 feet from the tracing line of the gun space, and parallel to it, their ends towards the rear, touching the tracing line of the passage in rear of the epaulments. The outer row of planks is laid parallel to these, 8 feet apart from outside to outside, and as the length of this recess is 20 ft. 6 in., three planks in each row are required, in addition to one laid just over the angle (Fig. 2, Plate II). Splinter proofs at least $3\frac{1}{2}$ inches thick, 8 feet long, and 9 inches wide, are laid on these, touching one another. These splinter proofs, &c., are brought from the rear of the battery and laid by the three diggers (d^2) of the gun portion facing the epaulment, the four diggers, two shovellers, and two rammers of the passage in rear, and the six shovellers and the three rammers, of the ditch round the epaulment.

The planks for the shell recess under the traverse are laid 3 feet from the tracing line, and 8 feet apart from outside to outside, two planks in each row, by the three diggers of the gun portion on each side of the traverse, and the four diggers and rammer of the passage in rear.

Splinter proofs are laid across the passage in rear of the traverse by the diggers of that ditch, as soon as they can work under them, resting on splinter proofs at each end. The space to be covered over should be 8 feet wide, and is for the purpose of covering the entrance to the magazine, which should not be in prolongation of the shell recess in the traverse (see Fig. 5, plate II).

Revetments. The slopes above the ground line are best revetted with fascines or sand bags; the cutting line forms the base of the interior slope of the battery, of the front and rear end of the traverse, and of the ends of the epaulments.

The bases of the interior slopes of the raised portions of the sides of the epaulments, and of the sides of the traverses, are 3 feet from the cutting line.

The revetment of the epaulments and traverses is not to be carried up above 2 feet, and that of the parapet above $2\frac{1}{2}$ feet, on the first night, in order that it may not be seen by the enemy above the screen; the fascines should be securely tied back with rope, wire, withes, iron bands or planks, to pickets driven into the solid ground about 7 feet inside the revetment, or to spikes fastened into the splinter proofs; these pickets must be driven, and the rope, &c., secured to them at the commencement of the work. If the soil be not stiff, it may be necessary to place the lower tier of fascines perpendicular to the cutting line, and if the soil be very bad indeed, and there is danger of its giving way if any weight be brought upon it, it may be necessary to leave a berm of 2 or 3 feet in width, the first night, and not make the revetment until the part below the ground line has been revetted; if the berm has to be left the first night, it will be advisable to revet the parapet the second night with gabions.

The whole of the revetting required on the first night can be done by eight

men, if fascines are used; or ten men, if sand-bags. This number includes fillers, carriers, and builders; half the men to revet the epaulments and the interior slopes as far round as the embrasures; the other half to do the portion between the embrasures, and also the traverse.

When the revetters have finished the revetment, they will be employed as shovellers on the parapet.

For every additional gun, four or five revetters will be required, according as fascines or sand-bags are used.

First Night. 2nd Relief. 3rd Relief.

During the second and third reliefs the following will be the strength of the working parties for a two-gun battery:—Five parties of miners, three in each party—that is, fifteen miners, and also six revetters.

Four parties of miners will commence mining out the shell recesses in the epaulments, one party commencing at each end of each recess; the fifth party will mine out the recess under the traverse; the shell recesses are to be sunk down only 3 feet if no cases are to be used, and made 3 ft. 4 in. wide, the centres coinciding with the centres of the splinter-proofs. In some soils cases may be necessary when the recesses must be 3 ft. 4 in. deep. The miners will also attend to the drainage of the battery; the gun spaces will be drained into the ditch of the epaulment nearest to them, the drainage channels being made close to the reverse slope of the passages in rear of the epaulments. They will deposit their earth on the berms, and on any convenient place, from which it can be shovelled on to the parapet during the second night. The revetters will revet the portions below the ground line, that are to be revetted, with hurdles or with fascines, securing these latter by means of stout vertical pickets tied back by ropes, &c., left for the purpose, the other ends of which have been secured to pickets driven into the solid ground.

For every additional gun the parties during the second and third reliefs, must be increased by three miners and four revetters.

If the ground be very hard indeed, a few men might be set to work to loosen the remaining portion of the gun space, by picking it over, but the earth must not be thrown on to the parapet, as this would attract the attention of the enemy.

SECOND NIGHT.

2nd Night, Gun Space.

Fig. 3, Plate II, shows the distribution of the working parties on the second night.

To complete each gun space, five diggers are employed, who will excavate the quantity remaining to be done, viz., one foot in depth over an area of 15ft. by 18ft. and slope off all the unrevetted sides, cutting away 9in. at the top. Three of the men (marked d^1 on plan), will stand in the portion already excavated to the full depth, their task will be 5ft. along the line, 10ft. to the rear and 1 ft. deep, they throw their earth on to the parapet. The other two men, (marked d^2 on plan), work from the passages in rear of the traverse and epaulment respectively; and have a task of 8ft. by 7ft. 6in., and 1 ft. deep; they throw the earth on to the traverse and epaulment respectively. These five men will after clearing out the gun space to the full depth, finish off the slopes, and assist to make the channels for the drainage.

Two shovellers will be employed—one on the berm of the traverse and the

other on that of the epaulment—to clear the berms of the earth excavated from the shell recesses. One rammer will be required on the traverse.

Ramp.

Five diggers are employed to complete each ramp to its width of 8 feet, and to make the slopes.

The first digger has for a task along the line—

	4ft. 0in.	giving about	93 cubic feet.
The 2nd D.	4ft. 0in.	„ „	88 „
„ 3rd D.	4ft. 6in.	„ „	80 „
„ 4th D.	5ft. 6in.	„ „	83 „
„ 5th D.	14ft. 0in.	„ „	82½ „

Front Ditch of Battery.

Fifteen diggers (marked d^3 on plan) are distributed in the ditch of the battery at intervals of 4 feet. Nine of the men occupy the space between the lines of fire, and three are on each flank of the others; their tasks are 4 feet along the line, 6 ft. 6 in. wide, and 4 ft. 9 in. deep, near the battery, but only 4 ft. 6 in. near the screen, making a total of 120¼ cubic feet.

Nine shovellers and five rammers are employed in connection with the above diggers.

Ditch round Epaulment.

Ten diggers (marked d^4) are distributed at intervals of 8 feet along the ditch excavated on the previous night. Their task is to deepen the ditch to 5 feet, and to slope the scarp, cutting away 1 foot at the top, making a total of 119 cubic feet.

Six shovellers and three rammers will be employed by these men as on the first night.

Estimate of Men, Tools, &c., 2d Night.

The following table gives the numbers of men, tools, &c., required for the construction of a screen battery, second night:—

Portion of Work.		Men.						Tools.					Materials, if revetted with		
													Fascines		S.B.
		Marked on Plan.	N. C. O. or Sapper.	Diggers.	Shovellers.	Rammers.	Total Infantry.	Axes, Pick.	Shovels, Field S.	Rammers.	Field Levels.	6ft. Rods.	Fascines.	Pickets, Bundles.	Sandbags.
For a 2-Gun Battery.	2 { Gun Spaces front	d^1	2	6	4	1	11	6	11	1	2	2			
	2 { Do. do. rear	d^2	0	4	0	0	4	4	4	0	0	0			
	2 Ramps	d	0	10	0	0	10	10	10	0	0	0	23	5½	440
	1 Ditch in front	d^3	1	15	9	5	29	15	29	5	0	1			
	2 { Ditches round Epaulment	d^4	0	20	12	6	38	20	38	6	0	0			
Total for 2-gun Battery			3	55	25	12	92	55	92	12	2	3	23	5½	440
For each additional gun.	Gun Space front	d^1	1	3	2	1	6	3	6	1	1	1			
	Do. do. rear	d^2	0	2	0	0	2	2	2	0	0	0			
	Ramp	d	0	5	0	0	5	5	5	0	0	0	12	3	224
	Front Ditch	d^3	1	9	6	3	18	9	18	3	0	1			
Total for each additional gun.			2	19	8	4	31	19	31	4	1	2	12	3	224

Revetters as 1st Night.
Miners as 2nd Relief 1st Night (if required).

PAPER V.

REPORTS ON THE PARIS EXHIBITION OF 1867.

TELEGRAPHY.

1. Description of the Austrian Military Telegraphic Equipment in the Paris Exhibition of 1867.—Pl. I.

By Captain R. H. STOTHERD, R. E.

The successful employment of the Electric Telegraph in all recent campaigns has had the effect of turning the attention of several European governments to the means by which an Electric Telegraph equipment, for use with an army in the field, may be made most effective. In the Paris Exhibition of 1867, specimens of the carriages, instruments, &c., used by the Austrians during their recent campaigns, were exhibited; and as the subject of Military Telegraphy is a comparatively new one, a description of them cannot be devoid of interest.

The carriage and other articles are simply specimens of those which would be combined to form an equipment to accompany any arm in the field. The following description is extracted from the notices published by the Austrian military commission at the International Exhibition.

"The application of the electric telegraph to military operations was initiated in the year 1854, under the superintendence of the officers of Military Engineers, and with the assistance of the employés of the Government Telegraphic Administration, and the existing system has been re-modelled as represented by the objects exhibited.

"The employment of a barrow so arranged as to admit of the wire being paid out or coiled up with facility, the reduction of the essential parts to convenient proportions, and the construction of portable apparatus, render the equipment generally available for field service.

"The chief use of a military field telegraph, which consists in keeping the head-quarters of an army in permanent communication with the telegraphic lines of the state, is thus attained without difficulty. A well arranged organization, under which it was possible to erect, keep in repair, or demolish lines of telegraph, was worked on this system, during the late war, in 1866, with considerable success. The method of laying and demolishing a line, is shown in the photographs exhibited.

"In general, a line 15,000 metres ($9\frac{1}{2}$ English miles or 2 Austrian leagues) long may be erected in half a day; but under favourable circumstances, (that is

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"In general, a line 15,000 metres ($9\frac{1}{2}$ English miles or 2 Austrian leagues) long may be erected in half a day; but under favourable circumstances, (that is

with flat and firm ground devoid of obstacles, and with able bodied soldiers, well instructed and practised in the duty), this might be done in two hours.

"The station waggon forms a Telegraphic Office, fitted with instruments, &c., ready to commence work directly the line is erected, in whatever position it may terminate.

"These carriages have however been found so extremely heavy, that latterly the apparatus only has been carried, and an office has been established at any point where convenient shelter is available.

"The organization of a military telegrapic corps would afford a treble advantage. 1st. By keeping in perfection, the necessary appliances forming a military telegraph equipment. 2nd. By familiarising the army with this new branch of warlike art; and 3rd, by affording the means of obtaining, even under the fire of an enemy, results which are only practicable when soldiers are employed, and which it could not be hoped to obtain with civilians. Up to the present time, however, the Minister of War has confided the military telegraphic service to the administration of the government telegraphs, which has charge of the material, consisting of one station waggon, and 20 myriameters (40 Austrian leagues), of wire; but it has recently been decided that, in time of war, military asistants and waggons shall be placed at the disposal of that administration."

I will now proceed to describe in detail the carriage and apparatus exhibited.

Travelling Office Waggon. The carriage is a travelling office waggon, and is shown in accompanying sketch, Pl. I., Figs. 1, 2, and 3; its total length is 14 feet, and it stands 9 feet 6 inches high; it is mounted on strong carriage springs, and fitted with a pole to be drawn by two horses; there is a driving box or seat for three persons in front; the wheels are of the ordinary size, but look small in consequence of the great height of the carriage. The top consists of a heavy imperial, for carrying stores and apparatus.

The entrance is by two doors, one on each side of the carriage, (see Fig. 1), and the bottom or floor is made very low to facilitate stepping in and out. There are plate glass windows in the door, in the front and rear side panels, and in the back; an outside shade blind is carried at the point (*a*, *a*) Fig. 2, which can be let down at an angle over the back window when required.

Carriage lamps are placed in front for night travelling, as well as to facilitate search for the carriage in the dark. Fig. 3, shows a rough plan of the interior; a very broad table (*b*) is fixed in the rear, on which a single Morse ink recording instrument is firmly screwed, its line, earth and battery terminals being permanently and conveniently arranged, to enable it to be rapidly connected for work or disconnected at will. The line and earth terminals are carried to the point (*e*) Fig. 1, where these connections are made, by means of binding screws, over which a small projection of a semi-circular form is placed to prevent loss of insulation from moisture or falling rain.

There is room for a second instrument on this table; this would be desirable in the event of the office forming a central station. A lamp is arranged on one

side of the table for night work, and the batteries could be conveniently placed under it. The great interior height of the carriage gives considerable facility for standing up, and in the front is fitted a desk (*c*) Fig. 3, of convenient height for writing in that position (standing up); under this desk are drawers for the stowage of spare instruments, stores, &c.; the general arrangement of the desk and drawers is shewn in Fig. 4. A large boot marked (*d*) Fig. 3, under the driving seat, also serves for the conveyance of stores, or for the men's kits, &c.

The carriage as a whole is very strongly built, and the fitments, both external and internal, display excellent workmanship; it formed a most convenient office for the officer in charge of the Austrian Military Exhibition.

The weight of this carriage, either empty or packed for service, was not given, and in answer to several questions on this important point, I could only ascertain that, with every thing complete, it is an extremely heavy load for two horses, and that considerable difficulty was experienced in getting it over a bad road; this is a very serious defect in a military point of view; from its general appearance, and taking the above-mentioned facts, into consideration, I scarcely think its weight can be less than 25 cwt., even on the most moderate computation.

Telegraph instrument.

The telegraph instrument which is fitted, as already stated, on the table of the travelling office, is a Morse ink recording instrument with a relay, of the form manufactured by Leopolder of Vienna. The clock-work of this form of instrument is made very compact, it occupying a space less than half that of the ordinary arrangement; this is a very great advantage as regards stowage and portability; in other respects, the fitments, and mode of working are precisely similar to the ordinary Morse instruments with relays.

Batteries.

The batteries used are of the Marie Davy form, (consisting of graphite and zinc plates, in a solution of sulphate of mercury), for the main line, with a few cells of Smee's pattern for the relays.

A small portable battery of the above nature is exhibited, consisting of nine Marie Davy cells and two of Smee's fitted into a strong wooden box, 15 inches long, 6 inches wide, and 6 inches deep; the lid of the box is fitted with india rubber stoppers, similar to those of a portable ink bottle; these correspond exactly with the openings at the top of the cells, and when the lid is shut, fit tightly over them, thus preventing leakage of moisture.

The cells themselves are of ebonite, and seem to be precisely similar to those manufactured for this form of battery by Messrs. Siemens Brothers, of Charlton. The two Smee's cells, (consisting of plates of zinc and platinised silver, in diluted sulphuric acid), are placed at one end of the box, the terminals of each group, being led through to binding screws outside the box, so that the connections may be made, when the lid is closed. A handle affords the means of lifting the box, which is sufficiently light to be carried in one hand.

This arrangement is adapted for a flying line, the necessary number of cells to work the instruments, according to the length and resistance of the conducting

wire, would be conveniently fitted in the travelling office itself when required for use, in connection with a line of considerable length.

Conducting wire.

The conducting wire used is No. 16 copper, uninsulated. It is coiled in convenient lengths, on drums, 2 feet in outer diameter, which can be transferred with facility to a barrow, so constructed as to admit of its being payed out or coiled up at pleasure. Copper is one of the best metallic conductors of electricity, and advantage is taken of this fact, in the present case, to reduce the diameter of the conducting wire, and its accompanying weight, with a view to portability. Copper wire of No. 16 Birmingham wire gauge weighs about 68 lbs. per statute mile.

Barrow for laying wire.

A barrow of peculiar construction, mounted on wheels, (Fig. 8), is used for paying out or coiling up the wire.

This consists of a wooden frame 5 ft. 6 in. long, and 2 feet broad; the wheels carrying it have a diameter of 3 ft. 4 in., and when stationary it is supported by legs *(f f)*, which fold up against the frame for travelling. The drum from which the wire is payed out is shown at (*g*) in sketch; it is 2 feet in diameter, and revolves on an axle, attached to that of the carrying wheels by a simple arrangement, so as to admit of its being shifted with facility.

The wire is payed out, over a roller (*h*), and through a slot (*j*), which carries it clear of the barrow in the direction required. The front view of this roller and directing arrangement is shewn in Fig. 9. In dismantling a line, the wire is coiled upon the drum by means of pinion wheels (*k* and *l*) and a handle (*m*), which works clear of the carrying wheel. By this pinion arrangemement, a multiplying motion is communicated to the drum, by which it is made to revolve much faster than the handle (*m*). This system would also serve to a certain extent, as a lever for stretching the wire in constructing a line.

Poles.

Poles, of strong well seasoned ash, are used to support the line wire; these are shown in Fig. 7; they are 16 feet long, the feet are shod with an iron spike, and an iron projecting arrangement is attached to the top (see section, Fig. 6,) to carry the insulator. The poles are 2 inches in diameter, and slightly tapering. They weigh about 15 lbs. each, with shoe and insulator complete.

Insulators.

The insulators consist of two parts, (shewn in Fig. 6,) viz., a vulcanised india rubber portion (*n*), about 2 inches across the base and 3 inches high, which fits tightly on to the iron projection (*o*) on the top of the post, and a glass cover (*p*), fitting firmly to the top of the india rubber. The glass cover is ribbed to receive the wire, which is attached to it by simply taking two or three turns round it.

Erection of a line of telegraph.

In forming a line of telegraph on this system, the wire is payed out from the drums, by means of the wheel-barrow, on to the ground; the necessary lengths are connected together and attached to the poles, by being passed two or three times round the glass portion of the insulators; holes are made in the ground by an iron jumper, and the poles, with the wire attached as stated, are raised and placed in them; the line thus formed is carried to the office waggon, and the operation of construction is complete.

Dismantling a line of telegraph.

The operation of dismantling a line of telegraph is precisely the reverse of the above. The poles are lowered, the wire detached from them and coiled on the drums, by means of the wheel-barrow and rack and pinion arrangement, already described.

Transport of wire and poles.

There is no special carriage for the conveyance of the wire and poles. They are simply packed, (the wire on drums), together with the barrow and other stores and apparatus, required for the construction of a line of telegraph, on the ordinary general service waggon of the Austrian army.

Magneto Dial Instrument.

Magneto telegraph dial instrument.

For special and temporary purposes the Austrians employ a Magneto dial military telegraph instrument, with an insulated wire laid on the ground.

One of those instruments was shewn at the Paris Exhibition, (see Fig. 5,) of the form constructed by Marcus of Vienna.

It consists of a letter-shewing Magneto dial instrument (*q*), supported on a wooden frame 3 feet long, with legs (*r*, *r*), which turn up when the apparatus is to be moved. There is a seat (*s*) for the operator. Straps are attached, as shewn in sketch, by which the whole arrangement, which weighs between 30 lbs. and 40 lbs., can be slung on a man's back for transport. A large umbrella is used with each instrument, to protect the operator from the sun or rain.

The telegraph instrument proper consists of a circular dial with the usual figures, blanks, and letters, arranged round the circumference. The current used is induced by means of an armature, on which four bobbins, wound round soft iron cores, are arranged in front of the poles of a powerful, permanent magnet, so that the current produced by breaking contact in one pair of bobbins, may be combined with that produced by making contact with the other pair, and a series of currents, of uniform quantity and tension, may thus be secured. The difference in strength between the current, induced by the act of breaking and that of making contact, is thus eliminated.

Motion is given to the armature and bobbins by means of a handle (*w*), in connection with a rack and pinion arrangement, and the letters are transmitted by means of the series of instantaneous currents induced by their rotation. The receiver consists of an electro-magnet, the keeper of which is a small permanent magnet, which is drawn to one side or the other, by the passage of a current, in one direction or the other and, being in connection with an escapement consisting of a ratchet wheel and pair of pallets, each current transmitted pushes forward the wheel to the extent of one tooth, producing a corresponding movement of the indicating hand of the dial of one division or letter.

The general principles on which this instrument is constructed are precisely similar to those of Wheatstone's dial telegraph instrument, the difference being simply one of construction. In Wheatstone's instrument, the armature abovementioned is made to revolve, the bobbins being permanently fixed on the poles of the permanent magnet. In the Marcus instrument the armature and bobbins

both revolve. There are no notches or other means of stopping the handle at the particular letter required, and consequently an operator requires some little practice, before he becomes thoroughly efficient, as the weight of the armature and bobbins causes a considerable tendency, when set in rapid motion, to overshoot the letter required. This is no doubt a defect in the instrument, but it is arranged so purposely, as the weight of the armature and bobbins would cause a tendency to break away, were any system of notches, by which the handle could be suddenly checked, adopted, as is done in several instruments of similar construction. A cover (v) closes the instrument in for transport, and the front (t) of the cover falls down towards the operator, and forms a place on which to write.

Insulated wire. The conducting wire, used with this instrument, is of copper or soft steel, No. 24 gauge, insulated to a total diameter of about a quarter of an inch with gutta percha. Great care is required in the storage and manipulation of this wire, as it is easily damaged by heat and dryness. When dry the gutta percha becomes very brittle, and liable to crack, when bent, and expose the metallic conductor. To form a line it is payed out from a reel or drum, by means of the barrow (Fig. 8,) already described, and allowed to lie on the ground.

In carrying it to the instrument, it is passed through an arrangement marked (x) Fig. 5, and thence to the binding screws of the instrument. This arrangement (x) contains three holes, two for the line wires, when the instrument is used as an intermediate station, and one for the earth wire. These are thus kept clear of the legs of the operator and other persons employed about the instrument.

This system is used in forming a telegraph line of short length for any temporary purpose, such as to communicate with a range party, during artillery practice. It is a totally separate equipment from the telegraph designed for use with the head-quarters of an army in the field, though it might of course be used in combination with it.

R. H. S.

II.—Description of the System of Submarine Mines, exhibited at Paris, in 1867, in the Austrian Military Department. (Pl. II.)

By Captain R. H. STOTHERD, R.E.

Submarine mines having now become an indispensable agent in the defence of coast batteries, harbours, and estuaries of rivers, any information bearing on the subject is worthy of attention.

The following description of the system of submarine mines exhibited at Paris in 1867, is translated from the notices of articles, shown by the Austrian War Department, published by authority.

" When it became necessary in 1859 to defend the ports of Venice by submarine mines, it was considered desirable to employ very large charges. The explosive action is, in such a case, sufficiently energetic to enable a line to be defended by a limited number of these machines. It was decided that charges of 224 kilogrammes (492·8 lbs.) should be used, and numerous experiments previously made, proved that the sphere of action extends to an average of ten metres from the centre of the mine.

" In order to fire these mines, (which are directly ignited by an electric spark), at any moment at will, it becomes necessary to determine the precise instant when a vessel comes within the sphere of action.

" To attain this object, a toposcope and other electrical instruments, previously described, have been employed. In certain cases, a camera obscura could be used, if specially arranged for the purpose, or an electric stadiometer. Several drawings and a model represent the construction of these mines, and their mode of immersion and anchorage.

" This system requires observatories, ready constructed some time before they are required for use, and well trained observers, a very great drawback when it is necessary to defend a coast line of considerable extent.

" On this account preference was given to self-acting torpedos, (the circuit being completed by the actual contact of a vessel passing over them, but the power of ignition still remaining under the control of the defenders), in the defence of Istria, in Dalmatia, during the past year (1866). This latter system requires a far smaller number of observing stations than the other, and it only becomes necessary to keep a good look out, and see whether an approaching vessel is a friend or foe. A second advantage of the self-acting system over other electrical combinations, is that the fuze is only placed in circuit at the moment a vessel is in contact; dangerous explosions, produced by the introduction of atmospheric electricity, are thus avoided.

" It is evident that a self-acting system of this nature requires an arrangement, producing an electrical current of constant force, ready to ignite the charge at any moment.

" This end is obtained by the employment of a special battery, in connection with a bobbin or coil of considerable length. The mechanism of the mine, put in motion by the impact of the vessel, introduces the fuze into the circuit, and simultaneously passes the current of high tension from the coil through it and ignites it.

" Another arrangement is used to connect all the charges of a line with the battery. This same apparatus serves to test the insulation of each line, as well as to indicate which of any given system of torpedos has been fired, so that its cable may be immediately detached, without which the current of the battery would be considerably reduced. The charge for a self-acting mine has been reduced to 168 kilogrammes (369·6 lbs.) of fine grain powder, the explosion only occuring when a vessel is actually in contact."

A full sized self-acting submarine mine, with all the necessary apparatus for immersion, anchorage, observation, and ignition, is exhibited, as well as numerous drawings, showing the construction and application of the system.

Submarine Mines to be Fired at Will.

I will now proceed to describe in detail some of the apparatus exhibited.

Form of case.

The form of case and arrangement of the charge of the submarine mine to be fired at will, is shown in the accompanying sketch;—Pl. II., Fig. 1, shows an elevation, and Fig. 2 a section—it consists of two strong wooden cases, one within the other, the inner one covered with zinc, and the space between them filled in with tar. It is of the shape of a truncated cone, but the diameter of the bottom is very slightly greater than that of the top.

The inner one has a mean diameter of about 4 ft., and is about 4 ft. in height; it is calculated to contain 4 cwt. of gun-cotton, made up in coils, and packed with plenty of air space, as shown in section Figs. 2 and 3; in these the air space is shown dark. The conducting wire, insulated with gutta percha, is carried through a stuffing box (*a*) Figs. 1 and 2, through a second stuffing box (*b*), and through the fuzes (*c*), in the centre of the charge, and to earth.

Fuze.

Two fuzes are always used to prevent the chance of a miss-fire, which might occur with a single one, if defective. The fuze was designed by Baron Von Ebner, Colonel of the Austrian Imperial Corps of Engineers, and is shewn in elevation and section in Fig. 4; it consists of an outer cylinder of gutta percha covering, an inner core (*d*), composed of a mixture of sulphur and ground glass, cast round the conducting wire, which is in the first instance in one continuous length, the opening (*e*) being subsequently made in it, in such a manner as to secure a uniform break or interval, in the conductor of each fuze; each opening is carefully gauged before the explosive composition is put in the space left for it..

In the first instance the core (*d*) was made of gutta percha, but this substance is easily affected by heat, and many fuzes were destroyed by the conducting wires becoming displaced when the gutta percha was in a soft state; there is no chance of injury on this account with the mixture of sulphur and ground glass, which is moreover a very good insulator.

The composition to be ignited by the electric current, consists of equal parts of sulphuret of antimony and chlorate of potash, to which is added a small quantity of powered plumbago, the latter to give a certain amount of conducting power to the composition for testing purposes. This mixture is put into the hollow (*f*) of the fuze, under pressure, the terminals being connected with a very sensitive galvanometer in circuit with a small battery during the operation of filling, and the pressure applied so as to obtain, as far as possible, a uniform resistance in each fuze.

Prussian Fuze. A fuze on similar principles is used by the Prussians; it is shown in sketch, Fig. 5; (*g*) is a small cylinder of hard wood, through which the conducting wires are drawn to the hollow space (*h*) in the centre; similar precautions being taken to secure a uniform break in the wire conductor to those adopted in making the Austrian fuzes; the hollow space (*h*) is then filled in with precisely the same composition as that used by Baron Von Ebner, and the opening stopped with a cork, shown at (*i*) in sketch.

Mode of firing charges. The charges are arranged to be fired at will, either by Von Ebner's frictional machine, of which several different specimens varying in construction are exhibited, or by means of a battery in connection with an intensity coil, as will be hereafter described.

Mode of mooring. In the Adriatic, where there is almost no tide or current to disturb submarine mines or cause them to revolve and twist up their mooring chains, a very simple arrangement for keeping them in the required position has been found effectual.

This is shown in sketch, Fig. 6, which gives the form employed with the original gun cotton charges, which were arranged to be fired at will. It consists of a simple wooden platform, of triangular form, on which heavy weights, marked (*k*) in sketch, are placed at intervals; this platform is attached to the charge by three wire ropes, in connection with its angles, which are fastened to three chains holding the charge, at any required depth below the surface of the water, by means of an arrangement shown in sketch, Fig. 7.

This consists of a pulley (*l*) attached to the extremity of the wire rope of the platform, through which the mooring chain of the charge is passed, and fastened by a key, marked (*m*), at the required length, by means of a pair of self-acting catches, passing through its centre, and catching a link of the chain at any depth required. This key allows the chain to pass through it one way, but directly a pressure is exerted in the opposite direction, the chain is caught by it and the charge held at the proper depth below the surface.

In connection with the self-acting submarine mines, more recently adopted, a mushroom anchor has been used. This mode of mooring is said to have been quite effectual in the still water of the harbours of the Adriatic, but from recent experiments made at Chatham, it is doubtful whether it would answer even in a very ordinary tideway or current, as the mooring chains, would be very likely to twist themselves up, in a very short time: the action of the current would probably cause the charge to revolve, and gradually entangle the mooring chains, if three were used, unless the three mooring chains were extended very far apart.

Self-Acting Submarine Mines.

In consequence of the difficulty of obtaining a sufficient number of well trained and trustworthy men for employment in the very numerous observing stations which would be required for the defence of a coast line of any considerable length by means of charges to be fired at will, it became necessary to devise some simpler system, for the working of which men of less skill could be made available. To meet the above-mentioned requirements, the following system has been approved by a committee of military engineers of the Austrian Service.

Iron case for submarine charges.

In the accompanying sketch, Figs. 8 and 9 show an elevation and section of an iron case, calculated to contain about 3 cwt. of gunpowder. It consists of an outer cylinder (*a*) at the top of which is a series of projecting buffers, held in position by strong brass springs, by the contact of which the circuit, from the firing battery through the fuze, is completed by a vessel coming in contact with the charge, as will be hereafter explained; these buffers are shown in sketch at the points (*b*, *b*, *b*); within the outer case a second iron cylinder (*c*) is placed to contain the charge of powder, a sufficient air space, to give the required buoyancy, being allowed by the difference in size of the cases. An insulated wire is carried from the firing battery through the stuffing boxes (*d* and *e*), through the fuzes (*f*), and, through the contact arrangement, to earth, and when the latter is moved by a vessel coming in contact with the case, the charge is fired. The outer cylinder, in the full sized model exhibited, is about 4 ft. in diameter, and 4 ft. in height.

Circuit closer.

In this system the submarine mines and circuit closer, are, as already stated, in the same case. The details of the circuit closer are shown in Fig. 10 and 11; (*b*, *b*, *b*) are the buffers held in position by strong brass springs, the openings through which they pass being kept water tight by means of strong macintosh cloth; when pressed in they would come in contact with, and cause to revolve, a brass ratchet wheel (*g*), also kept in position by a strong spring.

Strong pieces of wood (*h*, *h*, *h*) round the circuit closer keep the buffers and their attached arms in the proper direction, and give rigidity to the part of the iron cylinder through which they pass.

The brass ratchet wheel (*g*), being put in motion, carries round with it a central arrangement (*i*), the lower part, (that nearest the fuze), of which is shown in detail in Fig. 11. This central portion consists of a brass cylinder (*k*) divided into two portions, insulated from each other by a division of ebonite (*l*), shown in black; one side of this cylinder is fitted with three arms of brass (*m*, *n*, and *o*), and the other with two arms (*p* and *q*), all of which are carefully insulated from each other by india rubber. The arm (*m*) is close to, but insulated from, a metal plate (*r*), which latter is permanently connected with the conducting wire from the battery, and thus in its state of rest remains electrically charged. Beyond the arm (*n*) is a small spring (*s*), permanently connected with the earth, and in such a position that when the central portion is moved round, this spring (*s*) comes in contact with the arm (*n*) and the plate (*r*) with the arm (*m*) simultaneously, and the circuit is completed through earth to the battery, without, however, passing through the fuze.

Referring again to Fig 11, the arms (o and p), on opposite sides of the brass cylinder, and consequently insulated from each other, are connected with the fuze, and the arm (q) is permanently connected with the earth.

We left the current passing from the battery through the arm (m), by the brass cylinder, to the arm (n) and by the spring (s), then in contact therewith, to earth, and completing the circuit; but by a still further pressure of the vessel on the buffer, the arm (n) is pushed beyond the spring, and contact therewith, and consequently circuit by earth to the battery is broken, while the contact of the arm (m) and plate (r) is still retained and the current is passed by the arm (o), through the fuze to the arm (p), and thence to earth, through the arm (q) completing the circuit through and firing the fuze.

The action of the spring, in breaking the circuit, has the effect of intensifying the current, induced in the coil in connection with the firing battery, to its utmost extent, and at the moment when its intensity is highest, passing it through the fuze.

Should a friendly vessel be approaching a line of mines arranged on this system, it would only be necessary to detach the battery by removing the connecting plug, to render her passage perfectly safe. Should she make contact with any of the mines in her course, the ratchet wheel (g) Fig. 10 would be pushed round, the spring (s) would make and break contact as before described, but no current would be circulated, and on the vessel leaving the mine the ratchet wheel would be drawn back to its original position, by means of a strong spring in connection with it, and be ready again to act when required. The arrangement for closing the circuit is made sufficiently strong to prevent chance of injury from contact with a friendly vessel.

Mode of mooring.

The self-acting submarine mines are arranged to be moored by means of a mushroom anchor of the form shown in sketch Fig. 12. Attached to the anchor is a wire rope, connected to the mooring chain of the charge by a pulley and key, as already described in sketch Fig. 7.

Fuze.

The fuze used for the self-acting mines is Von Ebner's, it is placed in the centre of the charge, in contact with a pound or two of gun cotton. The charges are fired from a single point of ignition, two fuzes being always arranged in circuit to avoid the chance of a miss-fire, which might occur with a single one.

Batteries.

The batteries used were designed by Baron Von Ebner, Colonel of the Austrian Imperial Corps of Engineers, and are described as follows, in the notices of objects exhibited by the Austrian War Department:—

"These batteries may be considered a modification of that known as Smee's.

"The large quantity of liquid contained in the cell retards considerably the tendency to alter its internal resistance; platinised lead is used instead of platinised silver for the negative pole of the battery; and zinc, cut up into pieces and held in a bath of mercury, the whole in a porcelain cup, pierced so as to admit the diluted acid freely, forms the positive pole of the battery.

"The consumption of zinc and mercury, which is very considerable in the ordinary battery, is thus materially diminished.

"These batteries have been employed for some time in working a system of telegraph instruments of dial form. In this case the force of the electric current required is very small, but so little zinc was consumed, that the batteries worked for 18 months without being touched."

The general form of one of these cells is shown in sketch, Fig. 13. It consists of a vessel of glass (*t*) 18 in. deep, and 5 in. in diameter, to contain the diluted sulphuric acid, within which is suspended a plate (*u*) of platinised lead, which is bent round into a cylindrical form to fit close round the inner surface of the glass; in the centre of this latter is hung the porcelain perforated cup containing the cut up zinc and mercury, to keep it (the zinc) amalgamated; this is shown in elevation at (*v*) and in section at (*w*). The top of each cell is furnished with a porcelain cover, through which the wires attached to the positive and negative plates pass for convenience of connection. They are arranged in a wooden frame in batteries of 12 cells each.

Testing table. With the self-acting arrangement, it is manifest that after the fuze has once been put into the charge, it is impossible to test its condition. It is stated that one reason why it has been so arranged is that charges had occasionally been fired by atmospheric electricity, and that it is desirable, in consequence, to put the fuze in circuit only at the very moment of firing. It is possible, however, to test the insulation of the conductor, as well as, in the event of a charge being fired, to be able to identify which it is, and for these purposes a simple testing table, as shown in diagram, Fig. 14, has been devised; (*c z*) represents the battery with one pole to earth at (*e*), and the other in connection with an intensity coil (*a*) through which the current passes to the contact plate (*b*). When it is desired to put the system of mines in connection with the table in a state of preparation to be fired by the contact of a vessel, a plug is inserted between the contact plates (*b* and *f*), and the current passes through and electrically charges the conducting wires, shown by dots, connecting the charges with the battery, through the several binding screws (*g*, *g*, *g*,); as soon, therefore, as a vessel makes contact, the circuit is completed as already described, and the charge fired.

It then becomes necessary to ascertain which particular mine of the system has exploded; for this purpose the plug is placed so as to connect the contact plates (*b* and *d*), the current is then passed on to the testing circuit, shown by the firm lines, in which a galvanometer (*h*) is placed, and which is in connection with two metal bars (*i k*, *i k*); on these bars, and slipping freely along them, are metal points (*l* and *m*) sufficiently long to complete the circuit from them to the binding screws (*g*, *g*, *g*).

In a state of rest these points are thrown back into the position in which (*l*) is shown, and no current passes beyond the bars (*i k*, *i k*); when, however, the point is turned over into the position in which (*m*) is shown, the current passes into and electrically charges the insulated wires communicating with the mines; in this way each of the binding screws (*g*, *g*, *g*) is put in circuit in succession, and on the current's arrival at that one in connection with the charge which has been fired, the galvanometer will be deflected, as the circuit will be completed

by the broken end of the conducting wire, through the water and back by the earth plate to the battery.

Testing insulation of lines connecting mines to battery.

In order to test the insulation of the lines connecting the mines with the battery (the firing circuit), it is only necessary to place the plug between the contact plates (*b* and *d*) and touch each of the binding screws (*g*, *g*, *g*) in succession; should the galvanometer (*h*) remain stationary, the insulation is good; but should a leak exist, the current passing through it will act on and deflect the galvanometer, indicating the particular line in which it exists, which should be at once detached, as the current lost through it might so diminish the working power of the battery as to prevent its firing any of the fuzes in the same group. For the same reason the conducting wire of an exploded charge should be at once disconnected from the binding screw. By the above arrangement the insulation of the lines can be tested at any moment required.

To disconnect the battery.

In order to make the channel safe for a friendly vessel, it is only necessary to remove the plug from between the contact plates (*b* and *f*) and insert it between (*b* and *d*), or leave it out altogether; this disconnects the battery from the firing circuit.

Great care should be taken to keep the metal points (*l* and *m*) always thrown back, except at the moment when required for use in testing, in order to avoid the chance of accidents.

Several other forms of testing table were exhibited, some of them arranged for firing charges at will; that above described seemed, however, the simplest and best adapted for the self-acting system.

Placing submarine mines in position.

The submarine mines are placed in the required position by means of a mooring lighter or barge, sufficiently large to move heavy weights with facility.

They are lowered into their places by means of a pair of shears, erected at one end of the lighter, and attached to their moorings by the simple method already described, the moorings having been previously lowered into position in a similar manner. The conducting wire, having been attached to the charge, is paid out from a drum, and connected with the shore.

This system of submarine mines possesses the advantage of comparative simplicity; the circuit-closing apparatus, however, being somewhat complicated. The self-acting arrangements admit of its being worked by men but little acquainted with the theory of electricity. It possesses the disadvantage common to most purely self-acting systems, viz.: inability to fire a charge at will. The range or space defended by a charge is therefore limited to that within which a vessel comes into actual contact with the case containing it, and is consequently very restricted. In the Austrian system this inability to fire any given charge at will is rendered absolute, from the fact that the fuze is only put in circuit at the moment of contact of a vessel. The fuze, too, cannot be tested after the charge has been submerged, and the arms or buffers of the circuit-closer being very short, the space covered by them is comparatively small.

R. H. S.

III.—Description of Telegraphic and Electrical Apparatus in the Paris Exhibition of 1867. (Pl. III).

By CAPTAIN R. H. STOTHERD, R.E.

The employment of the Electric Telegraph and Sub-marine Mines, fired by electrical means, as acknowledged and indispensable agents of modern warfare, renders the science of electricity a necessary part of the education of all officers of Engineers. The following detail of some of the apparatus, exhibited at Paris in 1867, may therefore prove interesting, not only as a description of the instruments, but as displaying some of the many interesting and beautiful results to be derived from the more delicate combinations employed.

I have endeavoured as much as possible to classify the several objects described, so as to give facilities for reference and comparison, and for this purpose will begin with

Submarine Conducting Cables.

Henley, London, submarine cables

In the British section, Henley, of London, exhibits some specimens of submarine cables; these show a small length and section of the forms of several cables already laid. There is nothing peculiar about their insulation, which appears to be Chatterton's compound and gutta percha, but advantages are claimed for the outer protecting wire covering, which is laid on in a peculiar manner; its use can only be decided by practical tests.

Hooper, Pall Mall, London, submarine cables.

Hooper, of London, exhibits in the British section, several specimens of submarine cables, some of which are already laid.

Mr. Hooper has obtained a gold medal for the insulation of these cables, which stands a very high test, besides possessing many other most essential qualities tending to the efficiency and durability of the line when laid.

The general principles on which they are constructed are as follows:—a metal conducting wire, generally of copper, covered with an alloy, to protect it from chemical action; over this is a thin coating of raw india-rubber; then a thin coating, called the separator, of india-rubber mixed with oxide of zinc; over this is a thickness of vulcanized india-rubber, more or less, according to the amount of insulation and protecting covering required, and the outside protected by tarred hemp and iron wire, or, where the cable is not to be subjected to such usage as to render an outer wire covering necessary, by a simple layer of india-rubber felt. In the process of manufacture, the india-rubber, after being laid on, is subjected to a very high temperature, under a pressure of steam at 300 degrees Fahrenheit, which fuses it into a solid mass, and while thus improving the insulation, renders it indestructible by heat of any degree likely to occur even in a tropical climate.

The object of the separator is to prevent the sulphur of the outer or main insulator, penetrating to and attacking the metal conductor.

The high degree of insulation attained is due to the use of india-rubber, which is an excellent *di-electric*, and its capabilities in resisting high temperatures have been very severely tested, in the existing lines in Ceylon, India, and the Persian Gulf, most favourable reports of which have been received. The advantages claimed for his cable by Mr. Hooper, are summed up briefly, as follows:—high insulation, flexibility, and capability of withstanding dry atmospheric heat, which would destroy gutta percha.

Rattier et Cie., Paris, submarine cables.

In the French section, Messrs. Rattier et Cie., of Paris, exhibit some specimens of submarine cables, manufactured by them.

They are insulated with gutta percha, and have an external covering of tarred hemp and iron wire.

Morse, Newark, New Jersey, U S A., method of laying and raising deep sea telegraph cables

In the section appropriated to the United States of America, Mr. Morse, of Newark, New Jersey, exhibits a new system of laying and lifting submarine telegraphic cables. Whatever may be the merits of this system, its ingenuity renders it worthy of notice.

In carrying out his system, Mr. Morse proposes to use two ships, as shown in the accompanying sketch, Pl. III., Fig. 1, where (*a*) represents the large vessel from which the cable is payed out; (*b*) shows a second or smaller vessel, over the stern of which the cable is supported till the catenary curves, on both sides, to the points (*c* and *d*), where it touches the bottom, are complete; the second vessel then moves off at right angles to the course of the cable, gradually letting the latter down till it lies on the bottom.

The slack thus obtained is made available for raising the cable when required for repair; for this latter purpose, Mr. Morse proposes to use a mooring arrangement, of the form shown in Fig. 2; this consists of a metal cylinder (*e*), which surrounds the cable, attached to which, by a metal bar (*f*), is a conical arrangement (*g*), with arms pointing downwards; this conical device is attached, by a light mooring line, to a long pointed buoy (*h*), which floats on the surface, to indicate the position of the cable.

The mooring line holding the buoy (*h*), is not sufficiently strong to raise the cable, and, in the event of anyone attempting to pick it up without the necessary apparatus, it would break, while the cable would not be disturbed. When it becomes necessary to raise the cable, a ring (*i*), to which is attached a strong chain or rope, to carry the weight of the cable, is passed over the buoy (*h*), and guided over the conical arrangement (*g*), by the light line, this catches under the projecting arms and gives the necessary means of raising the cable at will. The ring and strong cable attached is shown at (*i*). This mooring arrangement having been lowered at the point (*k*), Fig. 1, it is evidently only necessary, in weighing it, to send down and hook in the ring, and proceed back in the opposite direction to that in which the cable was laid, viz. from (*b'*) to (*b*), when the slack thus obtained would prevent any heavy strain tending to break the cable, which must, however, be of sufficient strength to bear its own weight when suspended at the interval required in this operation.

The advantages claimed for this system are facilities for bringing a cable to

the surface for repair, and the means of regulating the amount of slack allowed to be paid out.

Mörath, Vienna. System of suspending submarine cables.

In the Austrian section, Mörath, of Vienna exhibits a system by which he proposes to suspend submarine telegraphic cables at a certain distance above the bottom of the sea, by means of buoys composed of cork and tar surrounded by an iron covering. He supposes that if the iron be decomposed by the sea water, the corks and tar will still remain and buoy up the cable. The advantages claimed for this system are the prevention of injury to the cable by the friction against rocks, &c., and a means of suspension over declivities in the bottom of the sea. He proposes to moor each buoy in such a manner as to secure the depth and direction required.

Subterranean Conducting Wires.

Nicholl, Kilburn, London. Mode of laying underground conducting wires.

I will now proceed to notice some of the most interesting objects exhibited having reference to conducting wires laid underground. Mr. Nicholl, of Kilburn, exhibits in the English section a system for laying conducting wires underground, which seems to present great advantages. He lays his conducting wires in bitumen, separated from each other by an interval of half an inch between each, and the whole in a troughing of iron, of the form shown in section at (*a*) Fig. 3. The wires are previously prepared by being covered with some fibrous substance and placed in these troughs in convenient lengths of from 11 ft. to 22 ft., and the bitumen run in so as completely to surround and insulate them from each other and from the sides of the case; the wires projecting from one side of the trough are arranged on a twisted form, see (*b*) Fig. 3, while at the other end they remain straight: the twisted ends are dipped in melted solder. This twist is made by means of a very ingenious little instrument specially adapted for the purpose. When it is required to lay a line, a trench is dug, the troughing and wire, previously prepared, are laid in it; the straight ends of the wire are passed into the twists and pressed together by a machine specially designed for the purpose, and soldered. A short piece of troughing, of a size larger than the main prepared lengths, is placed so as to connect their extremities, between which the newly formed connections lie; bitumen is poured in, in a melted state, to form the insulation, and a metal covering is laid over the top, upon which the earth is filled in, completing the operation. The wire exhibited by Mr. Nicholl is No. 16, copper, but the system is, of course, applicable to any size. Mr. Nicholl states that he can lay down subterranean lines on this system at a cost, where a large number of wires are laid in one trough, of £15 per wire per mile.* The advantages claimed by Mr. Nicholl are, economy where a large number of lines are to be laid together, as compared to an aerial line, safety

* Since the exhibition, Mr. Nicholl has improved his system by the use of papier maché for an outer covering, and in other ways; the principles, however, remain the same.

from injury when once laid, and high insulation. Its disadvantages are, the number of joints required, and the brittle nature of the insulating substance—bitumen.

Hetzmann, Amsterdam. Subterranean telegraph system.

In the Dutch section, Hetzmann, of Amsterdam, exhibits a system of laying conducting wires underground, which is very similar to Nicholl's.

He proposes to use insulated copper wires of No. 16 gauge, laid in an iron or wooden trough, and separated from each other at certain intervals by glass supports. When the wires have been thus arranged, the trough is filled with gas tar, which insulates them and keeps them and the glass supports in their places.

The mode of laying the wire is precisely similar to Nicholl's. The troughing, with conductors complete, is prepared in lengths, the ends of the wires being connected by an arrangement of twisted and straight pieces, similar to Nicholl's, and the interval connected by a short piece of troughing to fit over it and hold the gas tar, the top being covered with an iron or wooden cover.

The advantages and disadvantages of this system are precisely similar to Nicholl's.

Rattier et Cie., Paris. Subterranean telegraphic system.

In the French section, Messrs. Rattier et Cie., of Paris, exhibits their system of laying conducting wires underground. It consists simply of drawing the required number of wires, each insulated with gutta percha, and covered externally with tarred tape, through a series of cast-iron tubes of convenient length, a quantity of powdered talc being used to reduce friction. The intervals between the tubes are closed by a short piece of wider section slipped over, as shewn in sketch, Fig. 4.

The advantages claimed for this system are simplicity of laying and facilities for repair, and for the introduction of additional lines.

Leon Delperdange, Brussels Subterranean Telegraph System.

In the Belgian Section, Leon Delperdange, of Brussels, exhibits his system of laying conducting wires under the surface of the ground, Fig. 5, shows a section of this method, which consists of a simple metal tube, with an opening extending along the top from end to end. Insulated wires to any number required, are passed through this opening to the interior, the remaining space is then filled with water proof cement, and the top closed by a piece of ⊥ section wedged up as shewn in Fig. 5.

The advantages claimed for this system are facilities for repair, and for adding additional lines when required.

The subject of subterranean telegraphy is of considerable importance in a military point of view, and some system similar to any of the above, would seem to possess advantages for connecting the several parts of a permanent fortress or line of works covering a position, in such a manner as to afford protection from damage by an enemy's fire, while at the same time placing greater difficulties in the way of wilful or malicious injury than are presented by an aërial line.

Military Insulated Electric Cables.

Hooper, Pall Mall, London Military insulated cable.

In the British Section, Mr. Hooper, of London, exhibits several specimens of insulated wire suitable for military telegraphic or mining purposes, including submarine mines. The principles on which these cables are insulated are precisely those already enumerated in the description of his sub-marine cables.

Table (A) shows, in a compact form, the dimensions and weight of some of those exhibited. They are all designed to be laid on the ground, or on the bottom of the sea, and the outer protecting covering is modified according to circumstances to suit the amount of wear and tear, to which the cable may be subjected.

Where no very great amount of friction occurs, Mr. Hooper employs a simple covering of India rubber felt; when a connection is to be made over a rocky bottom, combined with a strong current or tide, he uses a protection of tarred hemp and iron wires.

Hooper's military cables have been very severely tcsted at the Royal Engineer Establishment, Chatham, and they are among the few specimens of several of different forms subjected to similar treatment, which remained in good working order, after the experiments, one of which was to pass a field battery of artillery over them when laid on a hard and somewhat gritty road, the metal used in the repair of which was flints.*

Siemens, Bros. Charlton, England. Military insulated cables

In the English section, Messrs. Siemens, Brothers, of Charlton, exhibited some specimens of light insulated cable for military purposes, suitable for telegraphic, mining, and submarine mining work. The construction of those first made may be described as follows. A conductor consisting of a strand of small wires, (steel or iron is most frequently used by Messrs. Siemens for this purpose). Next the wire a coating of Chatterton's compound, over which is gutta percha insulation, then a protecting covering of hemp, and finally, when required for rough usage, as on a rocky bed of a stream for example, a complete covering of copper tape, put on in a peculiar way by machinery. Messrs. Siemens hold a patent for this last process (the copper tape covering.) A conducting wire of this form, including the copper tapc covering, was used in the field telegraph equipment of both the Austrian and Prussian armies, during the campaign of 1866, and the result was, as originally prophesied by Messrs. Siemens, a complete failure and both have since given it up.

In our experiments at Chatham, it was among the first to fail when heavy carriages were passed over it, the outer covering of copper tape in most instances assisting in the destruction of the gutta percha insulation. There is no question therefore that it is not suited for military field telegraphic purposes. It would,

* A cable of very similar construction, manufactured by the India Rubber, Gutta Percha and Telegraph Works Company of North Woolwich, also stood remarkably well.

however, be very useful for short submarine lines, and is extensively used for that purpose by the Austrians, for connecting the Islands of the Adriatic. Messrs. Siemens have now modified their form of insulation, and use vulcanized india rubber, in some of their military cables, instead of gutta percha. They also, for some purposes, omit the copper sheathing and paint the hemp protecting covering with white lead. The attached table, marked (B), gives a comprehensive view of the general construction, weight and form of the more recent descriptions of military cable, manufactured by Messrs. Siemens, Brothers.

Messrs, Rattier et Cie, Paris. Light insulated wire.

Messrs. Rattier et Cie, of Paris, exhibit in the French section several specimens of light wire insulated with gutta percha* and covered with tarred tape.

These conductors might be used for military purposes, being of the necessary size, but they are not specially made with that view.

Insulated Wire for Induction Coils, &c.

Madame Bonis, Paris. Fine insulated wire.

Madame Bonis, of Paris, exhibits in the French section several specimens of her manufacture of fine insulated wire. Her insulated conductors are intended for use in making the coils of inductions and telegraphic instruments and other similar purposes, and with this view she insulates her fine wires with silk or cotton. She also uses gutta percha for insulating some of the thicker wires for special purposes.

Aërial Conducting Wires.

Johnson and Nephew, Manchester, Engld. Uninsulated telegraph wire.

Following closely upon the lighter forms of insulated cables we come to aërial conducting wires, and among these, Messrs. Johnson and Nephew, of Manchester, exhibit, in the British Section, some very good specimens of iron telegraph wire. These are of three different sizes, and the breaking strain of each is as follows :—

Quantity Exhibited.	Size B. W. G.	Breaking Strain.
530 yards.	No. 3.	281 lbs.
900 „	„ 8.	200 „
790 „	„ 11.	95 „

The numbers in the second column refer to the Birmingham wire gauge. The advantages claimed for these wires are good material and a high breaking strain.

* Twice coated with gutta percha, Chatterton's compound being placed round the conducting wire.

A substance called Mastic Machabée is used as an insulator by some of the exhibitors in the French section. It consists of a composition of $\frac{9}{10}$ gutta percha, and $\frac{1}{10}$ Stockholm tar. Its efficiency for practical purposes appears to require further trial.

Messrs. Renan et Cie, Paris. Uninsulated telegraph wire.

Messrs. Renan et Cie, of Paris, exhibit in the French section, a specimen of telegraph wire manufactured by them. It is three millimetres in diameter (about $\frac{12}{100}$ inches). The length exhibited is 1234 metres (about 1350 yards); weight 68 kilogrammes (about 150 lbs.) and breaking strain 43.8 kilogrammes (about 96 lbs). The advantages claimed for this wire are good quality and high breaking strain.

Apparatus used in forming Aërial Lines.

Vauzelli, Paris. Apparatus for stretching and completing an aërial line wire.

In the French section, Vauzelli, of Paris, exhibits a complete assortment of apparatus, for stretching and completing an aërial line of telegraph, together with some specimens of joints, iron hoods for insulators, and other objects of this nature connected with telegraphy. These seem to be very good of their kind.

Telegraph Posts.

Next in succession I propose to notice some of the forms of telegraph posts exhibited, in which iron has been brought into requisition, to replace the ordinary wooden poles.

Messrs. Siemens Bros., Charlton. Iron telegraph posts.

In the British section, Messrs. Siemens, Brothers, Charlton, exhibit an iron telegraph post. This is constructed as shewn in Fig. 6, and consists of a wrought-iron buckled foot-plate, (*a*), a cast-iron lower part (*b*) with flange, fitted to the foot plate by screw bolts and nuts, and with a socket to receive the upper post (*c*), consisting of a welded wrought-iron conical tube, with a boss at the top for the reception of the lightning rod, (*d*), which projects 18 in. above the post.

When erected this post stands 16 feet above the ground, (not including the lightning rod), with 2 ft. 6 in. in the ground. All the parts are dipped into hot drying oil to prevent rusting.

The weight of an intermediate post, capable of bearing a lateral strain of 4 cwt., without breaking, is about 160 lbs., and the cost £1. 2s. 6d. each. The weight of a stretching post, that is to say, one of a stronger construction, capable of bearing a strain of 6 cwt. without breaking, is about 200 lbs., and the cost £1 13s. each.

The advantages claimed for these posts are great durability, and they might perhaps be advantageously employed in countries where wooden posts are not procurable. The prime cost of erecting a line with them would, however, be very great.

French telegraph direction. Iron Telegraph Post, manufactured by Messrs Renan et Cie, of Paris.

In the French section an iron telegraph post, manufactured by Messrs. Renan et Cie, of Paris, is exhibited by the Telegraph Direction; this is something similar to that exhibited by Messrs. Siemens, Brothers, and consists of a lower cast-iron tube, fitted with a socket to receive the upper portion, which is formed of iron of a + section.

The advantages claimed for this form of post are strength and durability. The prime cost, would of course be greater than that of wood.

Insulators for Aërial Lines.

French Imperial direction of telegraphs. Insulators.

In the French section, the Imperial Telegraph Direction exhibits some very simple forms of insulators, which though not new are deserving of notice on account of their simplicity. They are of the form shewn in Fig. 7, and consist of a glazed earthenware cup, carrying a hook on which the wires are suspended. The whole is attached to the telegraph post by screws as shewn in the figure. These insulators are much used in France, and would seem to answer all the purposes required for a dry climate. They are not however suitable for damp countries or when great strength is required. They possess the advantage of being very cheap.

Messrs Siemens, Brothers, of Charlton. Insulators.

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit some of their forms of insulators, which are of very good quality, combining strength with high insulating power. The general form of these insulators is shown in Fig. 8; the insulating substance used is fine porcelain, in a cup form, and well glazed. In the process of manufacture they are compressed by machinery, which by preventing the chance of porosity or cracks, gives them great electrical resistance.

The wire is supported by a hook held in the cup, which is made in such a form as to grip the wire; the hook is fastened in by a cement of sulphur and iron filings; and the whole is protected by a cast-iron outer bell, which is screwed against the post. An elevation of this insulator is shewn at (*a*), and a section at (*b*).

A spank-off, or stretching insulator, is required at about every 500 yards; the form of this is shown at (*c*). It is precisely the same in principle as the other, but, instead of a hook, carries an arm with two notches. The wire is laid in one of these notches and secured by an iron wedge, a loop is then formed in it (the wire), and it is passed through the other notch and secured by a second wedge; these wedges must be so placed that the strain on the wires may draw them in slightly, and not tend to pull them out. When it becomes necessary to tighten up or slacken out the line, one of the wedges is removed, and the wire can be re-arranged at pleasure.

Siemens's insulators are much used by the Russian Government for their telegraph lines across the steppes, where the distances are very great, and where the breaking of an insulator would consequently be less easily discovered and repaired: there is no doubt they are particularly well adapted for such situations. They are, however, comparatively expensive, each insulator costing 1s. 3d., and each spank-off 3s. 3d., in England. Messrs. Siemens have recently covered the hooks with hard india-rubber, which improves the insulation, but adds 3d. to the cost of each.

John Bourne, Derby. Insulators.

Mr. John Bourne, of Derby, exhibits in the British section some insulators of the form known as Varley's, see Fig. 9. They are made of glazed earthenware, which is very much cheaper than

porcelain, and, for ordinary purposes, equally effective. Varley's form of insulator is very much used on lines of telegraph in England.

The Spanish Telegraph Direction, Madrid. Insulators.

In the Spanish section, the Telegraph Direction of Madrid exhibits an insulator of the form shown in Fig. 10. It consists of a porcelain tube, supported by a wrought iron collar, to which latter is attached an arm for fixing it to the post. The top of the collar is covered by an iron lid. The wire is carried on a hook which allows it to slip freely through, as in Siemens's pattern; this hook is fixed into the centre of the porcelain tube, and projects downward from it, as shown in sketch.

Austrian War Department. Insulator for military field telegraph.

In the Austrian section, an insulator adapted for their military field telegraph is exhibited by the Austrian War Department. The form of this insulator is shown in sketch, Fig. 11. It consists of a vulcanized india-rubber cup, of the form shown at (*a*), made to fit very tightly over an iron projection (*b*), attached to the top of the telegraph post. A glass cup (*c*), to which the conducting wire is attached by simply giving it two or three turns round it, fits tightly over the top of the india-rubber insulator, completing the arrangement, which answers every purpose required in a temporary line.

Transmittng Keys.

I will now describe some of the most interesting of several forms of transmitting keys exhibited.

Messrs. Digney, Frs., Paris. Magneto transmitting key for Morse recording instruments.

In the French section, Messrs. Digney, Frs., of Paris, exhibit a magneto transmitting key, arranged to be used with the Morse recording instrument, with Siemens' polarized electro-magnet or polarized relay. This key consists of permanent magnets, placed close to, and parallel to each other, but not in contact. The north poles are all on the same side, and the south poles on the opposite side in similar position. Between the horns of these magnets is a Siemens's armature of soft iron, on which is arranged a coil consisting of a considerable length of fine insulated wire, the extremities of which are carried to binding screws for connection with the circuit of the instrument, arranged for the purpose. The armature is placed so as to make and break contract at a point about half an inch from the extremities of the permanent magnets, where the force of magnetic attraction is strongest. Fig. 12, shows an elevation, and Fig. 13, an enlarged section of the instrument; (*s*) and (*n*) are two rows of permanent bar magnets, arranged as above described, the upper ones with their north poles, and the lower ones with their south poles, in contact with the stout plate (*p*) of soft iron. Between the poles of this system, and oscilating in an angle of a few degrees, by means of a handle (*h*) in the frame between two screw points, is the soft iron armature, as long as the system is wide, cut in deep longitudinal grooves on opposite sides, as shewn in Fig. 13; in these grooves the coil (*c*), of fine insulated wire, is wound.

The play of the handle is limited by two adjusting screws, in the frame (*a*). When at rest the handle is held against the upper screw by a spiral spring (*s*) stretched between the handle and front of the triangular piece (*d*) on the top. One end of the coil of wire on the armature is attached to the screw (*r*) on the terminal (*k*), from which one connection goes to the line, and another to the screw (*w*), at the foot of the frame (*a*). The other end of the coil is connected with the metal frame supporting the armature, and through the axis (*f*) to the upright support (*q*) from which a leading wire goes to the terminal (*t*), and to earth. When a current arrives, the instrument being in circuit with the line, it goes from (*l*) over to (*r*) and (*w*), upper adjusting screw in (*a*), through the handle (*h*), axis (*f*), (*q*), (*t*) and to earth without traversing the coil. This is the purpose of the connection between (*r*) and (*w*).

When the handle is pressed down, the polarity of the armature is reversed, and a positive magnetic-electro current, which also circulates in the line wire, is induced in the coil; and by strengthening for an instant the polarity of the lower horn of the polarized electro-magnet of the receiving instrument, it draws down the armature attached to the lever, in connection with the printing arrangement; this, when once brought into contact, by this means, with the lower horn above referred to, is held there by the permanent magnetism of the system, till released by the transmission of a negative magneto-electric current which, by strenthening the polarity of the upper horn, causes the armature, attached to the lever of the printing arrangement, to pass over thereto, and having thus passed over, it would again be held in contact by the permanent magnetism of the system. The negative current required is induced by simply releasing the key (*h*), which is drawn up, by the spring (*s*) to its contact with the upper adjusting screw attached to the frame (*a*). The action of the handle is simply to make and break the contact between the armature, carrying the fine wire coil, and the poles of the permanent magnets, thus producing the series of positive and negative magneto-electrical currents required; and the length of the mark, printed on the paper at the receiving station, depends upon the duration of the contact of the armature, in connection with the printing lever, with the lower horn of the polarized electro-magnet of the receiving instrument, which corresponds with the duration of the depression of the transmitting key; a means is thus afforded of signalling any necessary combination of dots and dashes.

The mode in which this instrument is made to act upon the tongue of a polarized relay is precisely similar to the above, and requires no further explanation.

Messrs. Siemens Bros., Charlton. Magneto transmitting key for Morse recording instruments.

An instrument, precisely similar in all its details, is manufactured by Messrs. Siemens Brothers, of Charlton, England, and by Messrs. Siemens and Halske, Berlin. In the British section, one of these keys is exhibited by Messrs. Siemens Brothers, of Charlton. It is arranged in a strong teak box, for carrying; its weight is about 33 lbs., and price £13.

Breguet, Paris. Magneto transmitting key for Morse recording instruments.

In the French section, Messrs. Breguet, of Paris, exhibit a magneto-electric transmitting key for use with a Morse recording instrument, with a polarized electro-magnet or polarized relay. The principles of construction of this key are precisely the same as those of Siemens and Digney; it is, however, of much simpler construction. Fig. 14, represents its general arrangement: (*a*) is a permanent horse-shoe magnet, on the poles of which, coils of fine insulated wire (*b*, *b*) are wound in such a way as to insure an induced current, on making and breaking the contact of an armature (*c*). This armature (*c*) is fitted with a hinge, and motion is given to it by a handle (*d*); in connection with the handle is a strong spring, which, in the position of rest, holds the armature up and in contact with the poles of the magnet. A depression of the key breaks this contact, and causes an induced positive magneto-electric current to circulate, for an instant, in the coils (*b*, *b*), and also through a line wire placed in circuit by connection with the binding screws (*e*, *e*). The fine insulated wire of the coils is in one length, that is to say, the coils are connected together; and the two extremities of this wire being in connection with the binding screws, and, through them, with the line and earth, the circuit is complete.

The action of this instrument, on a polarized electro-magnet or polarized relay, is precisely similar to that of Siemens; electro-positive and electro-negative magneto currents being circulated, by the action of breaking and making contact with the armature between the poles of the magnet. The currents, however, produced by this instrument are not so strong as those produced by the more elaborate combination of Siemens or Digney, but it is much less bulky and heavy.

Lacoine. Exhibited by Breguet, Paris. Transmitting key for submarine lines.

One of the greatest difficulties experienced in submarine telegraphy is the retention for a perceptible time in the conducting line, (which is always carefully insulated and frequently of considerable length), of a portion of a previous charge of electricity, used in transmitting a dot or dash forming a portion of the message to be passed along it; and various devices have been used to get rid of this residual charge, and thus obviate the delay and inconvenience occasioned by its existence. One of these is an arrangement invented by Lacoine, and exhibited in the French section, by Breguet, of Paris. Its general design is shown in Fig. 15. In a state of rest, the transmitting key (*g d*) is kept in contact with a spring (*a*) in connection with the line wire, while the conductor from the pivot passes to the instrument and thence to earth, thus fulfilling the necessary conditions for receiving a message at any moment. To transmit a message, the key is depressed, which allows the spring (*a*) to ascend while the contact point (*b*) descends; this latter, (*b*), in its descent, impinges on a second spring (*f*) before the spring (*a*) has moved up sufficiently to make contact with the point (*e*), which latter is connected with the positive pole of the battery. It will thus be evident that the line wire is put in direct connection with the

earth through the spring (*a*), the key (*g d*), the contact point (*b*), and the spring (*f*), for a moment, during the descent of the key. As the key is still further depressed, the spring (*a*) makes contact with the point (*e*), and here the extremity (*g*) leaves it, breaking the circuit above described, but establishing a fresh one from the positive pole (*c*) of the battery to the point (*e*), thence by the spring (*a*) to the line wire, and back through earth to the negative pole (*z*) of the battery. As the key is raised, the converse of the operation above described occurs, and the line is again, for an instant, in connection with the earth, and during the short periods, when it is so in contact, any residual electricity is discharged.

Villette. Exhibited by Breguet, of Paris. Morse transmitting key.

In the French section, Breguet, of Paris, exhibits a Morse transmitting key, of very simple construction, invented by Villette, shown on diagram Fig. 16. It consists of a simple strong spring (*a e*), one end of which is in connection with the line wire at the point (*a*). When in a state of rest it is in contact with the point (*b*), and thence by the conducting wire, through the instrument (*f*), the circuit is completed to earth, and the system remains in a position to receive a message. When the key is pressed down it leaves the contact point (*b*) and forms a connection with (*d*), thus affording a passage for the current of the battery from its positive pole (*e*), through the key to (*a*), along the line wire and back by earth to the negative pole (*z*) of the battery, completing the circuit. The advantages claimed for this form of key are simplicity, cheapness, and durability; an axis and bearings, as well as the springs required in the ordinary arrangement, being dispensed with.

Telegraph Instruments.

Messrs. Siemens and Halske, Berlin. Morse embossing instrument, with relay.

We now come to the subject of Morse recording instruments, and among many forms exhibited, Messrs. Siemens and Halske, of Berlin, show, in the Prussian section, a Morse embossing instrument with a relay. In all embossing instruments a considerable amount of force is required to produce the necessary pressure, to indent the paper on which the message is received. This cannot always be effected by the electric current received on the main line wire, which should for this purpose generate the force exerted by the electro-magnet, drawing down the armature in connection with the printing arrangement; the working force of the current is frequently so much diminished by the electrical resistance of the line wire as to prevent the electro-magnet, formed by it, exerting sufficient mechanical force to mark the paper in the embossing system.

In the instrument exhibited by Messrs. Siemens and Halske, this difficulty is obviated by introducing a polarized relay into the main circuit, the current through which completes, by means of its agency, the circuit of a local battery, which also includes the electro-magnet, in connection with the printing lever of the instrument, and acts on it, producing the force necessary to perform the mechanical work required.

Leopolder, Vienna. Morse embossing instrument.

In the Austrian section, Leopolder, of Vienna, exhibits a Morse embossing recording instrument with a relay, which is precisely on the same principle as Messrs. Siemens and Halske, but in a much more compact form.

The clock-work is contained in a very small compass, and everything is arranged so as to occupy as little space as possible consistent with efficiency. The instruments used in the Austrian field telegraph equipment are made by Leopolder, and are very similar in form to that exhibited by him on his own account.

Digney, Frs., Paris. A direct ink recording Morse instrument.

Passing to the ink recording Morse instruments, Messrs. Digney Frs., Paris, exhibit in the French section, a direct Morse recording instrument. The only difference between an ink recording and an embossing instrument of this nature is, that in the former the dots and dashes are marked in ink on the paper, instead of being indented, and the mechanical force necessary for this purpose is not nearly so great as that required for an embosser.

In Messrs. Digney's instrument the ink is supplied from a felt roller, kept constantly moist, to a metal disc ; and the paper, which is drawn through at a uniform rate by clock-work, is pressed upwards against this disc for a long or short interval, by an arm attached to an electro-magnet, in connection with the line wire in the usual way. This arrangement works admirably when in constant use, and has the advantage of requiring only a comparatively small mechanical force ; but when left stationary for any length of time, it requires some little care, as the ink in the felt roller dries up and clogs or blots, when the instrument is again started.

Siemens, Brs., Charlton. Direct ink recording Morse instrument, with polarised electro-magnet

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit a direct ink recording Morse instrument, fitted with a polarised electro-magnet. The peculiarity of this instrument consists entirely in the adoption of a polarised arrangement in the electro-magnet attached to it. Fig. 17 shows a sketch of its general construction: (*a*) is a permanent magnet, the two arms of which are at right-angles to each other; on one of the poles of this magnet, (the north pole in the present instance, but not necessarily always so), two soft iron cores surrounded by coils of fine insulated wire (*b*, *b*) are erected; on the outer extremities of these horns, so to speak, and projecting beyond the coils surrounding them, are two small anvils (*c c*), between which an armature (*d*), pivoted on the point (*e*), on the opposite pole of the permanent magnet, and forming one arm of the printing lever of the instrument, is free to move.

Polarity of a similar nature to that of the pole on which they are erected, is communicated to the two horns above mentioned; when, therefore, the soft iron armature (*d*) is placed in contact with either of them, it is held there by the permanent magnetism of the system. When in contact with the lower anvil, it raises the printing lever into the position of contact with the paper, and a long or short mark is printed, dependent on the duration of such contact; when

in contact with, and held by the upper anvil, the printing lever is drawn away and no mark is made. The means of transmitting any series of dots and dashes required is thus obtained, provided we can produce the necessary motion in the soft iron armature (*d*), which is done in the following manner: (*f*, *f*) are two small screws, so placed as to regulate the movement of the armature, so that it shall draw up to, and move away from the paper, the arm of the lever, in such a manner as to give the necessary pressure for printing, or remove it sufficiently far to give a decided blank space. Having regulated this portion of the arrangement satisfactorily, it then only remains to adjust the two anvils (*c c*) at such a distance from the armature that the permanent magnetic attraction exerted on it may be so balanced that the introduction of an electric current into the coils of the electro-magnet may, by strengthening the polarity of one or other of the horns, draw the armature to it. The means of altering the relative distance between these anvils and the armature, is afforded by the screw (*g*), which gives a slow motion to the upper one, while the lower one remains stationary, and the necessary adjustment is thus simply effected. The means of moving the lower anvil is given by a simple countersunk screw, which keeps it in its place, but when it has been adjusted this is rarely required.

When this instrument is used with a magneto induction key, the armature (*d*) is so balanced that a short positive magneto-electric current shall strengthen the polarity of the lower horn, to which it shall then be drawn down and remain attracted, tracing a mark on the paper as already described. The passage of a short negative magneto-electric current would reverse the combination thus formed, and by increasing the polarity of the upper horn, draw the armature to it, disengaging the printing lever from its contact with the strip of paper.

In using battery power, the system is so arranged that the passage of a positive current shall increase the polarity of the lower horn during the time it continues to circulate, the armature being attracted as before, while the distance of the upper horn is so regulated, that it shall draw the armature up by the action of its permanent magnetism when the circuit is broken, that is to say, when the current ceases to circulate.

The remaining details of the instrument exhibited are as follows:—The paper is drawn out at a uniform rate by clock-work, and the printing lever carries a disc which it lifts out of an ink bottle and presses on the paper in the same manner as is usual in most of the instruments constructed by Messrs. Siemens.

The advantages claimed for the polarized electro-magnet are, increased sensibility for obtaining the mechanical motion required, which obviates the necessity for the employment of a relay, and capacity for use with the magneto-electric transmitting key, already described.*

* The instrument adopted for the British Military Field Telegraph Equipment, as at present used for instructional purposes at Chatham, is fitted with a polarized electro-magnet, and seems to answer very well.

Messrs. Digney, Frs., Paris Morse recording instrument.

In the French section, the Telegraph Direction exhibits a Morse recording instrument, with polarized electro-magnet, manufactured by Messrs. Digney, Frs., of Paris, for military purposes.

This instrument differs only from that exhibited by Messrs. Siemens, Brothers, in the mode in which the printing disc is kept supplied with ink. In Digney's instrument this is done by a felt roller kept in contact with the disc, the paper being pressed up against the latter, to receive the required marks.

This instrument is made to fit into a knapsack, which also carries a small battery of Marie Davy form, with a few tools, and a small supply of paper—in fact, all the requirements for a small telegraph station in a very portable form. Messrs. Digney call this arrangement their "Poste Militairc."

Vinay, Paris. Morse ink recording instrument.

In the French section, M. Vinay, of Paris, exhibits a Morse ink recording instrument, in which the paper on which a message is to be recorded, is drawn along in an opposite direction to that in which the ink printing disc is made to revolve. The ink disc is in contact with a moistened felt roller, in connection with the clock-work, by which it is kept constantly revolving in one direction, while the paper, on which the message is to be printed, revolves in the opposite direction.

Fig. 18 shows the general design of this instrument:—(*a*) is an armature arranged to be acted on by an electro-magnet (*b*); when drawn down it raises the arm (*c*) in connection with it, and pivoted at the point (*g*); in this arm (*c*) is a slot, in which another arm (*h*), pivoted at the point (*i*) and connected by a rigid arm with the printing disc (*d*), is free to move; when the lever (*c*) is raised, motion is communicated through the arm (*h*) to the disc (*d*), and it is pressed upon the strip of paper moving over the roller (*e*). The felt roller (*k*) is made to dip into a reservoir of ink (*f*) as it revolves, which keeps it constantly moist.

A. F. Cacheleux of Paris. Morse recording instrument with Indian ink.

In the French section, Mons. A. F. Cacheleux, of Paris, exhibits a Morse recording instrument, in which he proposes to use indian ink and a drawing pen, in connection with the printing apparatus.

Fig. 19, shows the general arrangements proposed by him:—(*a*) is a drawing pen, resting in a vessel (*d*) containing indian ink, and connected through a pivot (*b*) with a lever (*c*), attached to the armature of an electro-magnet; when this lever is drawn down, the pen is raised, and comes in contact with the paper, passing over the roller (*e*), upon which the message is recorded; the paper is drawn along at a uniform rate by clock-work in the usual way.

The advantage claimed for this arrangement, is a clear, well defined mark on the paper; its disadvantage is the necessity for care as regards the indian ink, which is liable to clog when left for any length of time.

M. Hipp. Neuchatel. Morse direct ink recording instrument.

In the Swiss section, M. Hipp, of Neuchatel, exhibits a direct Morse ink recording instrument. This instrument is completely covered in to preserve it from dust. The writing beam works at right-angles to the direction of the clock-work, and an arrangement

has been adopted to keep it in a position during rest, on which a comparatively small current will act with effect. For this purpose, two springs (s, s'), Fig. 20, are attached to the writing beam (a) so as to act on it in opposite directions, and hold it lightly at rest in a neutral position. When acted on by the electro-magnet (d) through the armature (c) and the pivot (b), the force of the upper spring (s) assists in bringing it up against the paper. Conversely, when the current ceases to pass, the force exerted by the lower spring (s') draws it down again, and it is manifest that a considerable increase of printing power is obtained by thus balancing the springs lightly one against the other.

This is one advantage claimed for this instrument; another is the protection which its complete covering affords from injury or dust.

Longini & Dell Agua, Milan. Morse recording instrument.

In the Italian section, Longini & Dell Agua, of Milan, exhibit a Morse recording instrument, the peculiarity of which consists in the construction of the keeper of the electro-magnet, which is arranged with wire bobbins in such a way that the same current, which forms the electro-magnet, shall also magnetise the keeper with opposite polarity to the terminals with which it comes in contact.

In Fig. 21 (a, a') represents the horns of the electro-magnet, on which the usual bobbins of insulated wire are formed; (b) is the keeper, on the extremities of which (c, c') bobbins are also formed, the wire of which is in one continuous length with that of the electro-magnet. Now, supposing that the passage of the current produces a north pole on the electro-magnet at (a), and a south pole at (a'), the smaller coils are arranged so as to form a north pole at (c'), and a south pole at (c).

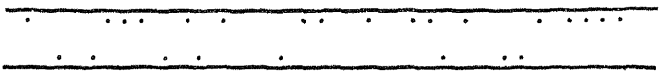
The effect of this is to increase the attractive power of the electro-magnet for the armature or keeper, in other words, to increase the sensibility of the system, and thus produce quicker action.

Spanish telegraph direction, Madrid. Double style Morse instrument.

In the Spanish section, the telegraph direction exhibits a double style Morse instrument of peculiar construction. In it the electro-magnet is placed in a horizontal position, and the armature or keeper is formed of a small permanent magnet, the horns of which play between the poles.

The transmitting key is shown in Fig. 22, and is arranged so that if pressed to the right a positive current is sent along the line, if to the left a negative current. A positive current thus transmitted acts upon the electro-magnet of the receiving instrument in such a way as to strengthen one of its poles and move the small permanent magnet forming the keeper in one direction, pushing up thereby one of two printing beams in connection with it, and making a mark on one side of the paper. A negative current received along the line wire strengthens the opposite pole of the electro-magnet, or rather reverses its polarity, and draws the armature in the opposite direction, pushing up the second printing beam, and making a mark on the other side of the paper. In this way letters may be transmitted in what is called the double style Morse

character, which differ from the ordinary Morse alphabet, in making a mark on one side of the paper to represent a dash, and on the other a dot, somewhat as follows:—

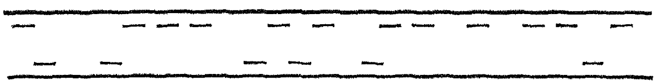


The paper is drawn out by an ordinary arrangement of clock-work. This instrument is also fitted as a sounder, with two bells of different tones, so that a positive current, drawing the polarized keeper in one direction, causes a small hammer to strike one of the bells, and a negative current causes it to strike the other. One bell represents a dash, and the other a dot; and after a little practice a message can thus be received by sound. The advantages claimed for this system are great speed and very small consumption of paper.

Gloesner, Liege. Ink recording instrument.

In the Belgian section, Gloesner, of Liege, exhibits an ink recording instrument of peculiar construction. He has arranged a magnetized needle, surrounded by coils of fine insulated wire, so as to produce deflections, as in the ordinary needle instrument. On this needle he has placed arms (*a*, *a*) carrying small discs (*b*, *b*), see Fig. 23, and when a current is passed through the coils in one direction or the other, these discs are brought down on the paper strip, which is drawn over a knife edge (*c*) by clock-work, and make marks on one side or the other, as required, which correspond to the dots and dashes of the double style Morse alphabet.

The characters printed by this instrument read somewhat as follows:—



Ink is supplied to the printing discs from two of Digney's felt rollers, so arranged that when one of them is in contact with the paper, the other shall be in contact with the ink roller placed above it, and vice versa.

The advantages claimed for this instrument are simplicity of transmission, which is reduced to that of the single needle instrument, and an increase of speed in sending a message.

Relays.

Leopolder, Vienna. Relay with terminals to reverse currents.

In the Austrian section, Leopolder, of Vienna, exhibits a relay with its terminals so arranged that the polarity of the electro-magnet may be reversed at will, to alleviate the effects of residual magnetism, which would tend to impair the instrument if the current were continually passed through in the same direction. Fig. 24 shows the design of this instrument. At the terminals of the line wire (*a*) are two plates (*b* and *c*), capable of being connected therewith by means of a contact plug; similarly, the terminal of the earth wire (*d*) is capable of being connected by a contact plug with either of the two plates (*e*) and (*f*).

The plates (b) and (e) are connected with one terminal of the coils of the instrument, and the plates (c) and (f) with the other, as shown in the sketch; and it is manifest that, placing the plugs between (a) and (b) and (d) and (f), the circuit between (a) and (c) and (d) and (e) being broken, the current must pass through the coils of the instrument from the terminal (h) to the terminal (k); while if the circuit is made between (a) and (c) and (d) and (e), and broken between (a) and (b) and (d) and (f), the current must pass in the other direction, viz.: from (k), through the coils to (h).

This relay is also arranged to be thrown ou[illegible] of circuit at pleasure, by the simple removal of a plug. The principle of th[illegible]ay be observed in the sketch. If the plug be removed from between the pl[illegible]a) and (l) and placed between (l) and (m), the current is cut off from the relay and passed direct to the recording instrument, or along the line wire, as required.

Messrs. Siemens, Bros., Charlton. Galvanometer & relay combined.

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit a galvanometer and relay combined. In this instrument the relay is on Siemens's polarized principle, with vertical bobbins, over which a magnetized needle is placed. When no current is passing, this needle remains attracted by the permanent magnetism of the system and is held in a stationary position. When a current is passed through the coils of the electro-magnet, its polarity is reversed, and the needle deflected accordingly.

Digney, Frs., Paris. Siemens's polarized relay.

In the French section, Messrs. Digney, Frs., Paris, exhibit Siemens's polarized relay. This instrument is constructed on precisely similar principles to Siemens's polarized electro-magnet, already described.—In Fig. 25, which shows its general construction, (a) is a strongly magnetized bar, the arms of which are bent at right angles to each other, and on its south pole is placed a horse shoe electro-magnet, both the soft iron horns (e, e'), of which have therefore communicated to them south polarity. (f) is a light bar of soft iron, moveable on an axis (c), fixed in the north pole of the magnet, and terminated by a light arm of platinum (d): (f) has consequently north polarity, and is attracted equally by (e, e').

The arm (f) is in permanent metallic connection at (c), with one end of the wire coil of the electro-magnet, in connection with the printing lever, while its extremity (d) is free to move between the two adjusting screws attached to the horns of the electro-magnet (e, e'); one of these adjusting screws (e') is insulated, while the other (e) is in metallic connection with one pole of a local battery, the other pole being connected with the other extremity of the wire coil of the printing electro-magnet, that is to say, with the extremity not in connection with the moveable arm (f), through (c).

When therefore (f) is held in contact with (e'), the circuit of the local battery is open; but when it passes over to the point (e) the circuit is closed, and the electro magnet, in connection with the printing beam, put in action. This relay has been designed to work with an induced magneto current, which is

precisely similar in its action to the polarized electro-magnet, already described: the coils of the electro-magnet (e, e') are so arranged that a positive magneto-electric current may, by strengthening the polarity of (e), draw the armature over to that side, and, closing the circuit of the local battery, put the printing electro-magnet in action.

If voltaic electricity be used with this relay, the adjusting screw points (e, e') must be so regulated that the permanent magnetism of (e') may have the preponderance over that of (e), so that, in a state of rest, the arm (f) may remain in contact with the former. The battery current is so arranged that it shall strengthen the polarity of (e), and draw the arm (f) over in contact therewith while it continues to circulate; but the moment it ceases, the permanent magnetism attracts the arm (f) back into contact with (e'). The circuit of the local battery, which acts on the printing beam of the instrument, is thus closed or broken as required by the transmission of the current along the main line.

The advantages claimed for this instrument are great sensibility of action and capacity for use with the magneto induction key. In consequence of its great sensitiveness, it can be used with a comparatively feeble current of electricity, which, though sufficient to put it in action, would be quite inadequate to produce directly, through the electro-magnet of the printing apparatus, a sufficient mechanical force to work the lever of the latter efficiently.

Automatic Morse Systems of Transmission.

There are several instruments exhibited arranged for the transmission automatically of the Morse character, to send which, by hand, with the ordinary key, requires considerable skill and constant practice:—among these, the following are deserving of notice:—

Messrs Siemens Bros., of Charlton. Automatic Morse Transmitter.

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit an automatic Morse transmitter, capable of being used by any one unacquainted with the manipulation of the ordinary key. This instrument is shown in Fig. 26, and consists of a series of metal studs and bars representing dots and dashes, arranged to form the letters of the alphabet.

These are carefully insulated from each other by ebonite, but are all in connection with a lower metal plate, which is itself attached to the line wire communicating with the station to which it is desired to send a message.

An arm (a), the handle of which is of some insulating substance, is connected with the positive pole of the transmitting battery, by a flexible wire (b), and the letters are transmitted by simply drawing this point over the apparatus, and the long and short currents required are sent when the metallic point passes over the bars and studs, completing the circuit from the positive pole of the battery along the line wire, through the receiving instrument, to earth, and from earth to the negative pole of the battery; at the points where the insulation intervenes, between the metallic projections, the circuit is broken. In this way, the necessary combination of dots and dashes is printed at the receiving

station in the ordinary manner. The advantage claimed for this instrument is that, by it a message can be transmitted in the Morse character by any person of ordinary intelligence, without previous practice in manipulation.

Messrs Siemens and Halske, Berlin. Morse automatic system of transmission.

In the Prussian section Messrs. Siemens and Halske, of Berlin, exhibit an automatic system of transmission for the Morse character. In this system, type, having short and long projections to correspond with the dots and dashes of the alphabet, is arranged in a series of long troughs, as shown in Fig 27 ; opposite each trough is a key, exactly like that of a piano. The broad white keys are opposite long spaces or dashes; the narrow black keys opposite dots; and the centre broad black key opposite blanks; that is to say type, without any projections, to form the divisions between letters and words. In order to form a letter the keys corresponding to the dots and dashes required are depressed, commencing from the left; this has the effect of dropping the necessary type into a composing stick placed beneath to receive them. The right hand broad black key is then pressed down and releases a system of clock-work for a single revolution. In connection with this clock-work, by means of a crank, is a lever, which is by it pushed out along the centre of the composing-stick pressing the type dropped in closely up together, and pushing the whole into such a position that it shall be ready to receive the next combination required to form a letter. By this means a letter can be very rapidly put together ready for transmission.

The next process is to pass the stick under a small spring, which forms part of the circuit of the transmitting battery, and under which it is guided, by a system of wheels which hold it in position, while motion is given to it by a crank in connection with a ratchet wheel, and it is passed along at a uniform rate. In passing under the spring the latter comes in contact with the dots and dashes of the type, and completes the circuit of the battery, and during the depressions between the type, or at the blanks between the letters and words, the circuit is broken. In this manner the long and short currents to print the message are transmitted, and may be received on any instrument adapted for the Morse Telegraphic System.

Another instrument, connected with this system, sorts the type, that is to say, separates the dots, dashes, and blanks, so that they may be ready to be set up again when required.

This consists in simply passing them out of the type stick over three long troughs, very similar to those of the setting up apparatus, and allowing them to drop into their respective places, through holes of the size necessary to fit them. The type of the dots, dashes, and blanks are all of different sizes, the dots being smallest, the dashes next, and the blanks largest; it follows therefore that the narrowest will slip in first, while the broader ones will pass on till they come to an exit suited to their size, and the troughs are arranged accordingly; first an exit for the dots, next for the dashes, and last for the blanks, and the process of sorting consists in merely pushing the type through this apparatus when each falls into its own division with the utmost regularity.

The advantages claimed for this system are great accuracy and regularity in printing a message, and great rapidity of transmission. It is particularly applied to a case where a message has to be sent from a central station along several lines diverging from it. Another advantage is the capability of transmission, after the type has been set up, by any person unacquainted with the use of the Morse key, or even of the alphabet.

Messrs Digney, Frs., Paris. Automatic Morse system of transmission.

In the French section Messrs. Digney, Frs., of Paris, exhibit a system for transmitting the Morse character automatically. In their system, a strip of paper is prepared by passing it through a machine with three keys, by the depression of one of which a short mark or dot is punched out of it; by the depression of a second key a long mark or dash is cut out of it; while the third simply passes it forward for one space, leaving a blank of any length required. A spring gives motion to the paper at each depression of any one of the keys, and draws it forward for a uniform distance, the dots being on one side, and the dashes on the other. To transmit it is simply necessary to pass the paper slip over a metal roller, against which two springs press; one spring is over the dots, and the other over the dashes, and the roller and springs being in the circuit of the transmitting battery, that circuit is closed during the interval left by the holes in the paper, while it is broken during the passage of the actual paper itself. If, therefore, it is passed through at a uniform rate, the dots and dashes of the message will be transmitted with unerring precision, and printed at the receiving station.

The advantage claimed for this system is great speed. It is said that 35 words, or 175 letters per minute can be transmitted by it. It is, of course, capable of being used by any one unacquainted with the Morse character and manipulation; and the paper, once prepared, can be used to send any number of messages required from a central station, with the same facility as Siemen's type arrangement.

Automatic system of Starting the Clock-work of an Instrument.

Sortais, Lisieux. Automatic arrangement for starting the clock-work of a receiving Morse instrument from a transmitting station.

In the French section, Sortais, of Lissieux, exhibits a very ingenious mode in which he proposes to start the clock-work of a Morse instrument at a receiving station, by means of a current transmitting a message from a sending station. He effects his object in the following manner:—By means of the keeper of an electro-magnet in the circuit of the transmitting battery, he pushes up a small projection which is held down by a weak spring, which gears into the teeth of the last wheel of the clock-work. In connection with this spring, also, is a counterpoise weight, which is set free and falls down directly the spring is released, and the clock-work is thus set in motion. When the electro-magnet ceases to act, the spring, acting on the small projection in connection therewith, presses it down and catches in the teeth of the wheel of the clock-work, and is gradually drawn down by it, while the counterpoise

weight is drawn up; and when this latter reaches its position of rest, it prevents any further motion, and the clock-work is stopped.

By this arrangement, the clock-work continues to revolve for a very short time after the conclusion of a series of currents used in transmitting a message, and the requisite interval is secured before another message is sent.

Messrs. Siemens, Bros., Charlton. Mode of starting clock-work of a Morse instrument at a receiving station by the current from a transmitting station.

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit a mode of starting the clock-work of a Morse instrument at a receiving station. This is effected by an electro-magnet, the coils of which are in the circuit of the transmitting battery. The keeper of this electro-magnet carries a small arm which gears into the teeth of the last wheel of the clock-work, and which is drawn, when a current is transmitted, by the attraction of the electro-magnet; this is so arranged that the keeper shall be held by the force of the residual magnetism during the intervals between the successive currents forming the message. In this way the clock-work is released, and continues to revolve while a message is being received, and for a very short interval, depending on the effect of residual magnetism as above mentioned, after the last current of the series forming the message has ceased, thus securing the interval before the next message is transmitted.

Portable Telegraph.

Portable Morse Telegraphic arrangement in the Austrian section.

In the Austrian section, and close to Leopolder's table is a portable telegraphic apparatus. It consists of a table, on which an ordinary Morse ink recording instrument is fitted permanently in position. This table is carried on two wheels; erected on it, and facing the operator, is a cupboard containing the necessary instruments for a small telegraph office. The top of this turns over, and the sides of the table turn up, to cover the instrument during transit.

When in use, two carriage lamps, one on either side, give light to the operator at night. Projecting to the front, from the axle of the two carrying wheels, is a pole with a cross piece at the end for hand draught. The pole itself, carrying a small seat, on which the operator sits when at work, is supported by a single wheel, which serves to keep the table in a level position when at rest.

The batteries are carried in a recess attached to the table and behind the small cupboard above mentioned, and a reel with wire is also fixed to it. Fig. 28 gives a general idea of this arrangement. (*a*) is the table with the instrument, (*b*) the cupboard, (*c*) the pole carrying seat, &c., (*d*) the recess for the battery, and (*e*) the reel for wire. The wire employed is of copper, insulated with gutta-percha and protected by an outer covering of fine copper wire wound round it. It is intended to be laid on the ground.

The mode of outer protection, by a fine copper wire bound round it, is decidedly objectionable, as this outer wire would assist in the destruction of the insulation if a wheel passed over it.

This arrangement is designed for running out a line for any temporary purpose, but it does not appear to be intended for a military equipment.

Single Needle Telegraph Instrument.

Gloesner, Liege. Single needle instrument.

In the Belgian section, Gloesner, of Liege, exhibits a single needle instrument. In this arrangement he produces the deflections of his needles by means of an electro-magnet, between the horns of which a keeper, consisting of a light permanent magnet, is free to play; by a reversal of currents, he attracts this keeper to one side or the other at will, and the necessary deflections, as on the ordinary single needle instrument, are thus produced.

The advantage claimed for this instrument is, that the needle is made to move in what is called a dead beat, that is to say, a very decided deflection on one side or the other, and an avoidance of that vibration which sometimes occurs with the ordinary form of single needle instrument, when the battery power used is scarcely strong enough, and which occasions difficulty in reading a message.

Letter Dial Telegraph Instrument.

Wheatstone's military magneto letter-showing dial instrument, exhibited by the Secretary of State for War, London.

We now pass on to the non-recording letter showing dial instruments, and among the most beautiful of these is Professor Wheatstone's Military Magneto letter-showing dial instrument, exhibited in the model barrack of the British section, by the Secretary of State for War.

This instrument consists of two parts, a transmitter and receiver, to which a third, consisting of an alarum bell, is sometimes added. The transmitter consists of a permanent compound magnet, on the poles of which four soft iron horns, surrounded with fine insulated wire coils, are fixed. Two of these horns or cores are on the north pole, and two on the south pole, of the permanent magnet, and have consequently north and south polarity communicated to them. A soft iron armature, to which motion is given by a system of ratchet multiplying wheels, revolves in front of these bobbins, in such a manner that, when it is breaking contact with one pair, it is making contact with the other pair, as shown in Fig. 29.

In speaking of making and breaking contact, it must be understood in a qualified sense; there is no actual contact between the armature and the bobbins, but they approach so close that there would just be about room to slip a sheet of ordinary writing paper in between them. In Fig. 29, if (n, n', s, s') be the bobbins, and (a) the armature revolving in front of them, the latter is so arranged, that at the moment when it is breaking contact with (n and s'), it shall be making contact with (n' and s), and thus the difficulty occasioned by the uneven succession of currents, which would occur if only one pair of bobbins were used, is got over; for the coils are so arranged that, for example, in the

present position the larger, or breaking-contact current, induced in the coils (*n and s'*), is transmitted in the same direction as the smaller or making-contact current, induced in the coils (*n'* and *s*), and thus we obtain an even succession of currents, first in one direction, and then in the opposite; for as the armature continues to revolve, it first makes, and then breaks contact with the opposite pairs of bobbins, with great rapidity. On the top of the transmitter is a dial of a circular form, round the circumference of which are placed the letters of the alphabet, in regular succession, together with certain symbols, such as full stop, comma, &c.; and at the centre of the top, a mark, or starting point, to which the pointer is always directed when in a state of rest, before a message is transmitted. This hand or pointer is pivoted on an axis in the centre, in connection with the ratchet work of the armature, and moves with it, passing forward each time one division or letter, that a current of induced electricity circulates in the coils. Round the circumference of the circular dial is a series of finger keys, one for each letter or symbol, and beneath each key is a small arm, which is pushed inward when the key is pressed down, and held in that position by a small spring, in connection with it. A fine chain, just long enough to allow of one key being down at a time, runs completely round the instrument, and is so arranged that, when a key is depressed, any other, which may have been down before, is raised by it. Directly under the indicating hand of the transmitter, and in connection with it, is a second hand, which can pass freely round, when all the keys are up, but which is just sufficiently long to catch on the arm, pushed in by a key which has been depressed; when this lower arm is thus caught, a small spring in connection with it, and which forms part of the circuit from the coils of the transmitter along the line wire, to the receiving station, is pushed back, the circuit is thus broken, and the succession of currents stopped, though the armature continues to revolve. In transmitting a message, the crank, connected with the armature, is turned continuously with one hand, while the keys, corresponding to the required letters of a message, are pressed down with the other.

We now come to the receiving portion of this instrument. This consists of a smaller circular dial, with exactly the same letters and symbols round its circumference as that of the transmitter, with a small hand pivoted on the centre, revolving round it. Motion is given to this hand by an escapement, put in action by a polarized armature of small size, working between the horns of a small electro-magnet, in the circuit of the instrument and line wire.

This hand is made to work synchronously with that of the transmitter by means of the succession of instantaneous currents, first in one direction and then in the other, passing through the electro-magnet of the receiver, the polarity of which is reversed by each small current received, and the keeper moved from side to side accordingly. To transmit a message then, it is only necessary to turn the handle, giving motion to the armature, continuously, taking care that the hands of both transmitter and receiver start from the commencing point, and to put down the keys corresponding to the letters required;

this has the effect of transmitting the required succession of short currents, which, passing through the electro magnet of the receiving instrument, cause the keeper to vibrate exactly synchronously with the armature of the transmitter; and the circuit being broken when the required letter is reached, the hand on the transmitter and that on the receiver move forward over precisely the same segment of the circle, and stop synchronously at the same letter; a small button is attached to the top of the receiver to give motion mechanically to the escapement, so as to bring the hand round to the starting point when required. The alarum used with this instrument is a bell in connection with a system of clock-work, which is started by an electro-magnet; this attracts a soft iron armature, arranged to be held, during the passage of the rapid succession of currents, by the residual magnetism of the system.

Professor Wheatstone's instrument is one of the most complete of the dial class worked by a succession of currents. I have, therefore, described it thus minutely as, in so doing, the action of the others may be the better understood. The pair of instruments exhibited are arranged in strong oak cases, with a lid which shuts down, and in which is a handle for transport. Each instrument weighs about 24 lbs.; and its price is £26.

Its advantages are that no batteries are required, and that any intelligent man can learn to use it in a few hours.

Breguet, Paris. Letter-showing dial instrument.

In the French section, Breguet, of Paris, exhibits a magneto letter-showing dial instrument. This is on the same principles as Wheatstone's, but differs slightly in the transmitter. In Breguet's instrument, the handle, which moves the armature in front of the electro-magnet of the transmitter, works over the dial, and the succession of currents is stopped by arresting the handle simply over the required letter, and not by breaking the circuit as in Wheatstone's.

This is not such a quick method as Wheatstone's, but otherwise the advantages are much the same.

Messrs. Siemens, Bros., Charlton. Military magnetoletter-showing dial instrument.

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit a military magneto letter-showing dial instrument. The general principles on which this instrument is constructed are the same as Wheatstone's, but it differs in details. Messrs. Siemens replace the compound permanent magnet of Wheatstone's by a series of magnets arranged parallel to each other, but not in actual contact; and the armature, carrying its coil of wire, is made to revolve between the poles precisely in the same position in which it is placed in the Morse magneto key, Fig. 12. Motion is given to this armature by means of a handle in connection with a rack and pinion arrangement which works over the dial, round the circumference of which the letters are distributed; and opposite each letter is a notch, into which a projection beneath the handle slips when pressed down, to arrest it distinctly and sharply at any letter required. This latter is of very great use, as without it there is considerable liability to overshoot the point at

which it is necessary to stop the handle, the effect of which would be to send a wrong letter.

The receiver in this instrument is precisely similar to Wheatstone's, and consists of a small electro-magnet with a polarised keeper, the latter in connection with an escapement, which gives motion to a small hand on a dial marked in precisely the same way as that of the transmitter.

In the military pattern of this instrument, both transmitter and receiver are placed in a compact form in one strong wooden case, the whole in a stout leather cover with two pockets, in one of which are stowed the legs, and in the other the handle for giving motion to the armature, and a few simple tools connected with the instrument.

Messrs. Siemens, also exhibit a similar instrument of the pattern which they have supplied to the London Fire Brigade, which only differs from the former in having the receiver placed in a less compact form with reference to the transmitter.

The weight of the military instrument is about 40 lbs.; and its price £24. Its great weight is a decided disadvantage, in a military point of view.

Leopolder, Vienna. Military magneto letter-showing dial instrument. Exhibited by the Austrian War Department.

In the Austrian military section one of Leopolder's military, magneto, letter-showing, dial instruments is exhibited. The peculiarity of this instrument consists in the arrangement of the armature, which is here connected with four coils or bobbins of fine insulated wire, and the whole, (armature and bobbins), made to revolve over the poles of a system of permanent magnets. The dial is very similar to that of Siemens's, and working over it is a handle, giving motion, through a system of ratchet wheels, to the armature and bobbins. There are no notches to assist in arresting this handle at any required letter. This is so arranged, on purpose, as any sudden stoppage would be very liable to cause the armature and bobbins, which are rather heavy, to break away.

In sending a message, the transmittor has, therefore, to depend upon his own individual skill, and some little practice is required to prevent a tendency to overshoot the mark, caused by the momentum of the armature and bobbins. The receiver of this instrument is precisely similar to that of Wheatstone's, and consists of an electro-magnet, the keeper of which is a small permanent magnet, to which motion is given by the rapid series of inverted currents transmitted, and which acts, through an escapement, on the small hand traversing on the dial, as already described.

An alarum is sometimes combined with this instrument. It consists of two bells, between which a clapper, worked by an electro-magnet and polarized armature, arranged for a rapid series of inverted currents of small quantity and high tension, is free to vibrate. This system is connected by a switch with the line wire, and the current can be made to pass through it, or through the receiver, at will. The whole is mounted on a kind of hand-barrow, with legs which double up for transport, the instrument itself being furnished with a lid

to close it in, the front of which falls down and forms a small table for writing purposes.

It is provided with straps, so that it may be fitted, knapsack fashion, on a man's back; a small seat is also attached to it, for the benefit of the operator. The weight of the whole, complete, is about 30 lbs. Fig. 30 gives a general idea of its arrangements.

Breguet, Paris. Letter-showing dial instrument.

We now pass on to the letter showing dial instruments, worked by battery power, and among these one of the best is Breguet's well known instrument, exhibited in the French section at his own table, as well as at that of the telegraph direction.

The transmitter of this instrument consists of a dial, round the circumference of which the alphabet and several stops and conventional signs are arranged; over this dial a handle revolves, and in connection with this handle, is an arrangement for making and breaking the circuit of a battery, and thus transmitting a series of short currents of electricity as it moves. These are passed along the line wire and through an electro-magnet at the receiving station. Each time this electro-magnet acts, it draws up its armature and releases the escapement of the clock-work of the receiver, which moves forward one tooth, and gives a corresponding movement, to the extent of one letter, to the indicating hand of the dial. Thus, if the hands of the transmitter and receiver move simultaneously from the starting point, as the former reaches the letter A, a single short current is transmitted, and the clock-work of the receiver, for an instant released, bringing its indicating hand forward one tooth, or to the same letter. As the transmitting hand reaches the letter B, a second current is sent along the line, passing the indicator of the receiver on to B, and so on till the required letter is reached. The receiver thus works synchronously with the transmitter. Breguet calls this his *step by step* instrument, a name conveying in itself a very concise description of it.

Its advantages are that it can be worked by any one without much previous practice, and is so simple in construction that it is not likely to get out of order. It does not however record a message. It is very much used on the French railways.

Breguet exhibits one of these instruments in a box, arranged by Mr. Crossley, of Halifax, in Yorkshire. The lid contains the alarum, and when opened this is out of circuit. The centre contains the receiver, and the bottom the transmitter. There is nothing peculiar about this instrument, but it is very compactly and nicely arranged.

Letter Type Printing Telegraph Instruments.

We now pass on to that class of instruments in which the message as received, is actually printed in Roman letters. A great many very ingenious instruments of this class, are exhibited and among them some of the most remarkable are the following:—

Joly, Paris. Type printing recording instrument.

In the French section, Joly, of Paris, exhibits his type printing recording instrument. The general design of this instrument is shown in diagram Figure 31. The transmitter is of the ordinary dial form, very similar to Breguet's, arranged to transmit a series of currents by the revolution of a handle, as already described. These currents arriving along the line wire, put in action the electro-magnet (*g*) in the receiver, the armature of which carries a forked escapement arrangement (*h*), gearing into a wheel of the clock-work, which turns on the same axle as the type wheel (*i k*). On the circumference of the transmitter are the usual letters of the alphabet, corresponding to similar letters and signs round the rim (*k*) of the type wheel; a series of numbers, 1. 2. 3 . . . 9. 0 is arranged in a second circle on the circumference of the transmitter, which numbers correspond in relative position with those on the other rim (*i*) of the type wheel, and as this is made to revolve synchronously with the handle of the transmitter, as will be hereafter described, we have the means of bringing any letter or figure required to the printing point at will, supposing both, (the transmitting hand and type wheel), to move from the starting point simultaneously. The printing is performed by a local battery (*c z*) in connection with a system of clock-work. The circuit of this battery is kept open by means of a spring (*f*), which gears into a wheel of the clock-work, and is of such length that it vibrates more slowly than the teeth, into which it gears, revolve; it is thus kept constantly in motion while the clock-work revolves, but directly it stops, the spring falls into its place, makes contact with the point (*d*), closes the circuit of the battery, and sets an electro-magnet (*l*) in action, the armature of which releases the printing clock-work, which raises the press (*a*) and pushes the strip of paper against the type wheel, which is kept supplied with ink by contact, as it revolves, with a moistened roller. By the same motion, the paper is drawn forward one space or interval, so as to be ready to receive the next letter.

The mode in which this instrument is arranged to print either letters or figures, as required, is very ingenious. This is done by means of an electro-magnet (*m*), which is so connected that, when a series of positive currents is received along the line wire, one of its poles shall be strengthened and attract a polarized armature (*b*), drawing it on one side and through a pivot, moving the printing press (*a*) under the edge (*k*) of the type wheel, on which the letters are placed; similarly, a series of negative currents strengthen the opposite pole of the electro-magnet (*m*), or rather reverse its polarity, bringing the armature over, and placing the printing press under, the number rim (*i*) of the type wheel.

The advantage claimed for this instrument is simply that of printing a message at once in Roman type, and presenting it in a form intelligible to all, thus doing away with the necessity of a special alphabet, such as the Morse.

Spanish Telegraph direction, Madrid. Type printing instrument.

In the Spanish section, the Telegraph Direction of Madrid, (Sènor Ramonmorènes), exhibits a Roman letter type printing instrument. The principle on which this is worked is very similar to Joly's. There are two systems of clock-work, one to move the type-wheel, the other to lift the printing press. The type-wheel is made to revolve synchronously with the handle of the transmitter by means of a series of positive currents acting on an electro-magnet in connection with an escapement, as in Joly's instrument. The printing is performed by a local battery set in action by a device shown in Fig. 32, which releases a system of clock-work and raises a press to print, as before.

As the succession of currents arrives along the line wire they act on the electro-magnet (*b*), and cause its armature (*f*) to vibrate rapidly. In connection with (*f*) is an ivory arm (*a*), to the upper portion of which is connected by a conducting wire one pole of the battery (*c z*) the other pole having a metallic connection, through the electro-magnet (*g*) attached to the printing clock-work with the brass bar (*h*), to which are attached two contact points (*i, i*). Two light springs (*e, e*) are attached to the top of the ivory pillar, and two others (*d, d*) to the lower part of it, their points of connection being thus insulated from each other. These springs (*d, d* and *e, e*) vibrate when the ivory arm is set in motion by the action of the armature (*f*), and the two upper ones (*e, e*) are of such a length that, during vibration, they shall not work synchronously with the ivory arm itself, but by their simple motion shall keep the circuit of the local battery (*c z*) open. Directly the currents cease to be received, the motion of the ivory arm ceases, the springs come to a position of rest, the circuit of the local battery is completed, and the letter at that particular moment over the press is printed.

The advantages claimed for this instrument are precisely the same as those mentioned for Joly's.

Guyot D'Arlincourt, Paris. Letter type printing instrument.

In the French section, Guyot D'Arlincourt, of Paris, exhibits a letter type printing instrument. This is very similar in general construction to those already described, and its peculiarity consists in the arrangement by which the circuit of the local battery, by which the printing is performed, is closed. In this instrument, the armature of an electro-magnet in the line wire circuit, acts as a relay to the local battery. It is so arranged that this armature shall be too sluggish to move till a continuous current passes through the electro-magnet, and thus, during the succession of currents received while the type wheel is revolving, the circuit of the local battery is kept open; as soon, however, as the succession of currents ceases and a continuous current passes, the armature is attracted by the electro-magnet, the circuit of the local battery is closed, and the letter is printed.

Levin & Cie., Berlin. Letter type printing instrument.

In the Prussian section, Messrs. Levin & Cie., of Berlin, exhibit a letter type printing instrument. The peculiarity of this instrument consists in the absence of clock-work. The transmitter is

so arranged, that by the turning of a handle, a series of reversed currents shall be passed along the line into the receiver, which consists of an electro-magnet with a polarized armature in connection with an escapement, very similar to that of Wheatstone's dial instrument. The printer consists of a series of light springs, on the outer extremities of which are the letters; these are moved round synchronously with the transmitter, and when the required letter is brought over the printing press, the latter is raised by an electro-magnet. A second line wire is required for the printing arrangement. The advantage claimed for this instrument is the absence of clock-work in any shape, but it has the disadvantage of requiring a second line wire.

Desgoff. Type letter printing instrument, exhibited by Digney, Frs., Paris.

In the French section, Digney, Frs., of Paris, exhibit a letter type printing instrument, invented by Desgoff. This is one of the most promising of this class of letter printing instruments, and though not attaining the speed of Hughes' instrument, it still possesses many very excellent peculiarities. In it the type wheels of the transmitting and receiving instruments are made to rotate synchronously by two systems of clock-work, regulated by two arms corresponding to the zero or starting point in each. The first of these two arms, which comes over the electro-magnet, is held there till the corresponding one in the other system of clock-work reaches the same position, when the circuit of a battery is closed, and a current circulated through the coils of the two electro-magnets, by which two stops are pushed up, and both arms released simultaneously. The printing is performed by a relay battery without clock-work, the press being simply released by the formation of an electro-magnet.

The clock-work is not stopped during the process of printing. The type wheel is attached to it by means of a spring pressing on the pivot on which the whole revolves, in a very similar manner to that in which the hands of a watch are attached, and it is detained during the moment of printing; when let loose it flies round to the starting point, and the two arms are released simultaneously, as already described. The clock-work at the receiving station is started automatically by the current from the transmitting station.

The advantages claimed for this instrument are, synchronous action, which, adjusting itself at each revolution by a self-acting process, cannot possibly become disarranged; considerable speed in transmission is also attained; and the clock-work is not stopped while a letter is being printed.

Hughes' letter type printing instrument, exhibited by Dumoulin Froment, of Paris.

In the French section, Dumoulin Froment, of Paris, exhibits Hughes' letter type printing instrument. This is one of the most, if not the most, efficient letter printing instrument exhibited. The type wheels are kept moving, at the rate of 120 revolutions per minute, by clock-work, which is made to work, as nearly as possible, synchronously, by simply regulating it before sending a message. To do this it is only necessary to see that it gives a series of blanks when the blank key is put down several times in succession. The transmitting arrangement

resembles very much a piano, on the keys of which the several letters of the alphabet, together with numbers and several other conventional signs, are marked, each letter or sign having a separate key. These keys are simply contact makers, by which the circuit of a battery is closed, and they are so arranged that when that representing any particular letter is depressed, the circuit is completed when that letter arrives at a particular point in its revolution as it is carried round by the clock-work. At the same moment, the corresponding letter on the type wheel at the receiving station should be, by the synchronous arrangements of the instruments, directly over the electro-magnet attached to the printing gear, and this latter being released for an instant, the press rises, and the letter is printed on a paper strip placed to receive it.

The advantage claimed for this instrument is great speed, which it certainly attains; its arrangements, however, appear to be somewhat complicated. There is no doubt however that, if properly managed, it is a very efficient telegraph instrument.

Digney, Frs., Paris. A transmitting dial, worked by clock-work.

In the French section, Messrs. Digney, Frs., of Paris, exhibit a dial for the transmission of a succession of short currents, such as those required to work several of the forms of dial instruments, already described. This instrument consists of a dial, round the circumference of which are arranged the usual letters and signs. Over this dial a handle, having a point projecting downwards from its outer extremity, traverses; and corresponding to each letter and sign is a hole, through which the projection of the handle passes to the interior, which contains a system of clock-work, the escapement of which is so arranged as to transmit a succession of short currents as it revolves, by rapidly closing and breaking the circuit of a battery. Over this clock-work moves a hand which catches on the point of the transmitting handle above described, when the latter is put through any of the holes corresponding to the letters on the dial. and by which the clock-work is stopped. By this means it will be perceived that we have the power of arresting the hand of the clock-work at any letter required, as well as of transmitting any given succession of currents corresponding to the letters on the dial; and we have only to obtain an instrument capable of working synchronously with this transmitter, which will receive the message sent, to complete the system as a telegraphic combination.

The advantage claimed for this instrument is facility of manipulation. The transmitting handle turns either way, and is only used as a means of stopping the clock-work at any particular point; it is therefore more simple to use than a handle, which must be carried round and stopped over the letter required.

Telegraph direction, Madrid. Transmitter for a series of short currents.

In the Spanish section, the Telegraph Direction of Madrid, (Sènor Ramonmorènes), exhibits a dial transmitter with a handle working over its face and acting on an escapement, by which it closes and breaks the circuit of the transmitting battery as it continues to revolve. This handle moves round and is stopped at any letter required,

and thus any given series of short currents, corresponding to the distance traversed between the letters, is passed along the line wire to the receiving station. This is merely doing mechanically, what is effected by the clock-work in Digney's instrument.

The Spanish Telegraph Direction also exhibits a dial with figures round its circumference, made exactly on this principle. This is intended for signalling in cypher or by code.

Sounding Telegraph Instrument.

We now pass on to the subject of sounding instruments. These are very much used in America, and may be shortly described as the Morse instrument without its clock-work, or printing apparatus.

Messrs. Siemens, Bros, Charlton. Morse sounding instrument.

In the British section, Messrs. Siemens, Brothers, of Charlton, exhibit a Morse sounding instrument. This consists of an electro-magnet in connection with a local battery, the armature of which is arranged to strike, with a certain amount of noise, against its poles as it is drawn up by the force of attraction produced by a passing current. When the current ceases, it is drawn back, by means of a spring, against a small anvil, also with a slight click, and the interval between these two sounds gives the length of the current which has just passed; and the dots and dashes, corresponding to the long and short currents received, are thus measured. In the instrument exhibited, a second electro-magnet in the line wire circuit receives the currents composing the message, and its armature acts as a relay, by which the circuit of the local battery is closed. An ordinary Morse transmitting key is also attached for sending a message when required. This instrument is more portable than the ordinary form of Morse with clock-work, and is convenient in many ways, but it has the disadvantage of not recording a message.

Caton, Illinois. Portable Morse sounding Instrument.

In the section apportioned to the United States of America, Caton, of Illinois, exhibits a very compact little sounding instrument, of the pattern used by conductors on railway lines. In the United States, a system is very much used under which the current is always passing along the line wire, and signals are transmitted, not, as is usual in England, by completing the circuit of the transmitting battery, but by breaking it, and this little instrument is arranged to work on that principle.

It consists of a key designed to break the circuit, and an electro-magnet and keeper or armature, with a back anvil for measuring the duration of a current, and thus distinguishing between the long and short intervals, as before described. The whole is arranged in a small box with a cover, about 5 in. long, 4 in. broad, and $1\frac{1}{2}$ in. deep, to carry in the pocket. To use this instrument it is only necessary to break a line wire at any point, and attach the two ends of the broken pieces to its terminals, when messages can be transmitted by interrupting the circuit by means of the key, or they can be received by sound on the electro-magnet of the instrument, by an interruption of the current of the battery at the permanent station.

The advantages claimed for this instrument are great portability, and that it is unnecessary to carry a battery with it. It, however, could only be used on a line through which a current circulates continuously.

Copying Telegraph Instruments.

Le Noir, Paris. Copying telegraph instrument.

In the French section, Le Noir, of Paris, exhibits a copying telegraph instrument of very ingenious construction. Fig. 33 shows the general design of this arrangement:—(*a*) is a metal roller, in the circuit of a battery (*c z*), at the transmitting station; on this roller a piece of paper, prepared with silver so as to conduct the current, is placed, any figure or writing to be transmitted, having previously been drawn or written on it in non-conducting ink. This roller is made to revolve by clock-work. During its revolution the hand (*e*), also in the circuit of the battery (*c z*), passes round and round it with a gradually advancing motion, given by an endless screw, till it has traversed its whole surface with a series of lines, almost touching each other. While this hand (*e*) is passing over the conducting paper, a current of electricity passes continuously along the line wire to the receiving instrument; when it passes over the non-conducting ink, this current ceases. The receiving instrument consists of a roller (*b*), covered with printing ink, which is made to revolve synchronously with the roller (*a*), by clock-work, in a manner which will hereafter be described. Over this cylinder (*b*), on which paper is placed to receive a message, is suspended an arm (*f*), in connection with the armature of an electro-magnet (*d*). While a current continues to pass through the electro-magnet, the arm (*f*) is held up by the armature, but directly the current ceases, as it does when interrupted by the non-conducting ink on the paper round the roller (*a*), at the transmitting station, the electro-magnet (*d*) ceases to act, the point (*f*) falls down on the paper, placed on the roller (*b*), and a mark is made on it by the printing ink, in a position exactly corresponding to the ink marks on the paper on the roller (*a*). This point (*f*) has also a gradually advancing motion, given by an endless screw, similar to that of (*e*), and thus a fac-simile of the picture or writing is transmitted with great facility. When the impression has been taken, it can be transferred to stone and printed, or to another piece of paper, as long as the ink remains wet.

The clock-work at the sending and receiving stations is made to work synchronously in the following manner:—(*g*) is an electro-magnet in the line wire circuit, the armature of which is too sluggish to be influenced by the current of the transmitting battery (*c z*), but which moves when the current of the battery (*c′ z′*) at the receiving station is added to the former. This is done periodically by means of the roller (*h*), (in connection with the clock-work), which is composed of brass, and carries on its surface a series of ebonite plates (*i, i, i*), six in number, so arranged that when the conductor (*l*), connected with the earth wire is in contact with the cylinder (*h*), the conductor (*m*), connected with the zinc pole of the battery (*c′ z′*), is in contact with one of the ebonite insulating plates (*i, i, i*),

and vice versa, the main line terminal (*n*), being always in metallic connection with the brass cylinder (*h*). It is thus easy to perceive that, as the roller (*h*) is carried round by the clock-work, every time the contact point (*m*) comes on the brass or conducting portion of it, the contact point (*l*) being then over one of the ebonite bars (*i*, *i*, *i*), the current of the battery (c' z') is added to that of (*c z*), care being taken that the poles are so arranged that the current shall traverse both in the same direction, that is to say that the copper pole of the battery (*c z*) shall be next to the zinc pole of the battery (c' z'), as they follow each other in the circuit. Again, as the contact (*m*) comes on one of the ebonite plates (*i*, *i*, *i*), the current of the battery (c' z') is cut off, while at the same time the contact (*l*), being on the brass portion of the cylinder, the main line current passes through it to earth.

As already stated, when the current of the battery (c' z') is added to that of (*c z*), the armature of the electro-magnet (*g*) is attracted. This armature is arranged to act as a relay to a local battery, (c'' z''), which has in its circuit an electro-magnet (*k*), over which a star armature with six points, in connection with the clock-work, revolves. These six arms correspond to the six brass or conducting divisions of the cylinder (*h*), and are so arranged that they should be exactly over the poles of the electro-magnet (*k*), when the contact point (*m*) is passing over the brass or conducting portion of that cylinder, or in other words, when the current of the battery (c' z') is added to that of (*c z*), at which same moment the circuit of the battery (c'' z'') would also be closed, through the armature of the electro-magnet (*g*), and when, consequently, the electro-magnet (*k*) would be in action, and the star armature would be attracted. By this means the two systems of clock-work are made to work synchronously, for if the star magnet were a little behind time, it would be attracted forward, or if it were a little ahead, it would be held back. Practically, this system of synchronous working is found to answer very well.

The advantage claimed for this instrument is the power of transmitting an exact fac-simile of any message or figure required. A man's signature sent in this way, is quite recognisable. On close examination of a message received, it is seen to be composed of numerous very fine lines, in close proximity to each other.

Casseli, Paris, Copying telegraph instrument.

In the French section, is exhibited a copying instrument, invented by the Abbé Casseli. In this instrument the writing to be transmitted, is made on a silver plate, with non-conducting ink; this plate is put on a segment of a cylinder in the battery circuit, over which an arm, carrying a point, also in the battery circuit, is made to traverse backwards and forwards, to which also a slow lateral motion is given by an endless screw. The receiving portion consists of a similar segment of a cylinder over which chemically prepared paper is placed, to receive the message through an arm, working synchronously with that of the transmitter, passing over it. This arm and segment of a cylinder are in the battery circuit, and when a current passes, the chemically prepared paper is marked; where it is stopped, by the

interposition of the non-conducting ink, the paper remains white. A reverse of the original is thus obtained.

There is no clock-work used in this instrument, and the synchronous motion is obtained by means of the heavy pendulums, the oscillation of which is kept up by a system of electro-magnets, two to each. When the pendulums at both stations come in contact with these electro-magnets, the circuit is broken, and they are simultaneously released and fall by their own weight, closing in their descent the circuit of the battery, which forms electro-magnets on the opposite side; to these they are attracted, and again released simultaneously as before, and a synchronous oscillation is thus produced. These pendulums are also connected with the small arms and contact points passing over the transmitting or receiving portion of the instruments, which thus oscillate synchronously with them. There is also an arrangement with this instrument by which the message to be transmitted is placed in a box, secured by a lock on the transmitter, and is received in a similar locked up box at the distant station, which box can be detached and sent to its destination without being opened, and thus only the writer and receiver of the message are made aware of its contents.

The advantages claimed for this instrument are precisely similar to those of Le Noir's, viz.: the capacity for transmitting a message as written, that received being a fac-simile.

Automatic Transmission of Signals.

Bergmuller, Vienna. Automatic system for transmission of signals.

We now pass on to a class of instruments designed to transmit automatically a certain number of fixed important signals, and among these is one exhibited by Bergmuller, of Vienna, in the Austrian section. On a metal plate are engraved a certain number of signals, as above, and corresponding to each signal a number 1, 2, 3, 4, and so on; under each number is a wheel, in connection with a system of clock-work, and on each wheel are teeth, corresponding to the number attached to the signal, one for the first message, two for the second, and so on. These wheels are in the circuit of the transmitting battery, which circuit is completed by placing a moveable arm, with a spring projecting beneath it, also in the circuit of the battery, at the point where the figure, indicating the number of the message to be sent, is marked.

The clock-work is now started, and as it revolves, the projections on the wheels come in contact with the spring of the moveable arm, and complete the circuit, sending one, two, three, or more short currents along the line wire. These may either be received on an ordinary Morse recording instrument, or by beats on a bell, which would correspond to the numbers of the signals, and indicate the message required. The clock-work, after taking two or three turns, stops itself.

Two instruments of this nature are exhibited, one arranged for a railway, containing a few very important signals referring to the position of trains on a line, the other designed for police and municipal purposes; in this latter a small

finger key is passed in and held, mechanically; this releases the clock-work, and produces the necessary contact; it is intended for public use, and to be set up at certain points throughout a large city. The advantage claimed for this instrument is facility for transmitting a certain number of important signals with rapidity, and with a minimum of liability to error.

Breguet, Paris. Automatic system, for transmission of a few important signals.

In the French section, Breguet of Paris exhibits an automatic system, by which he proposes to transmit a certain fixed number of short currents to indicate a certain signal. The instrument exhibited is something on the same principle as Bergmuller's, and is designed to act as a call to any particular station along a line of railway, where there are frequently many stations in the same circuit. Each station is indicated by a certain number of beats, which are produced by transmitting the corresponding number of short currents, which release the clock-work of an indicator, and give the proper number of beats corresponding to the station required to be called. These short currents are transmitted automatically, in a very similar manner to that of Bergmuller, and are continued till the station called answers.

The advantages claimed for this system are facility for calling a station required, and the prevention of confusion or of the reception of a message at a wrong point.

Lightning Protectors.

A very important item in the fitments of every telegraph office are the lightning protectors; though in themselves small, they cannot be dispensed with.

Among the most novel forms of these instruments are the following :—

Picco, Alessandria. Lightning protector.

In the Italian section, Picco, of Alessandria, exhibits a lightning protector, in which he introduces a piece of very fine wire into the circuit between the line and the telegraph instrument.

The ordinary current used in working the instrument, passes along this fine wire without producing any result; but a heavy charge, such as that which would be likely to damage the coils of the instrument, would fuze this wire, and the line, which is arranged to be drawn down by a spring directly this occurs, would be brought into contact with an earth connection, and the current sent directly to earth.

Breguet, Paris. Lightning protectors.

In the French section, Breguet, of Paris, exhibits a lightning protector on a very similar principle. In his instrument, a very fine piece of iron wire, (a, a') Fig. 34, is placed in circuit between the line and instrument; this supports a small hammer (b), fastened by a hinge to the wooden frame (c). This fine wire would be fuzed at its extremity (a') by a heavy charge of electricity, because at that point it would experience a very considerable resistance, and the hammer (b) would fall by its own weight, against the contact plate (d), which is connected directly to earth, and the charge would thus pass off, without injuring the instrument, along the dotted line, which represents the broken wire.

In the same section, Breguet also exhibits a lightning protector with a kind of saw tooth arrangement. It consists of two metal plates, the lower one connected directly to earth, separated from each other by a thin sheet of paper. This opposes a sufficient resistance to prevent the ordinary working current passing away directly to earth; but should a heavy charge strike the line, it collects on the teeth and jumps off their points through the paper insulation to the lower plate, and thence to earth.

Leopolder, Vienna. Siemens's lightning protector.

In the Austrian section, Leopolder, of Vienna, exhibits a very well made specimen of Siemens's form of lightning protector. This instrument consists of two metal plates, about 3 in. square, placed flat on each other, and separated by thin strips of vulcanite, so that a certain metal surface in each may be in close proximity to, and yet not in contact with, the other.

The upper plate has binding screws, to which the line wire and instrument are attached, and the lower plate is connected to earth. The ordinary working current passes from the line wire to the instrument through the upper plate, the small interval between the plates offering a sufficient resistance to its passage to earth; while a heavy charge passing from the line would jump across this interval, and pass away without injuring the coils of the instrument.

The object of all these lightning protectors is the same, viz.: to afford a means for a heavy charge of electricity to pass away to earth without entering the coils of an instrument, which it would inevitably destroy.

Batteries.

Leclauché. Battery manufactured by Messrs. Bonner, Jamin, Bailly, & Co., Paris.

In the French section, is exhibited a form of battery, invented by Mons. Leclauché, and manufactured by Messrs. Bonner, Jamin, Bailly & Co., Paris. Fig. 35, represents a cell of this battery. The positive pole (*a*) consists of a plate of graphite in a porous jar, surrounded by a mixture of peroxide of manganese and graphite broken up into small pieces. The negative pole (*b*) is a plate or pencil of amalgamated zinc. The whole is in an outer glass cell (*c*) containing a solution of sal-ammoniac. The peroxide of manganese is a good conductor of electricity. This system may be described as a battery with one acid, and of which the positive pole has great affinity for hydrogen.

The endomosis, inevitable in a battery of two acids, is avoided in this combination. Zinc may be preserved for a very long period in a solution of sal-ammoniac, and peroxide of mangenese being quite insoluble in that liquid, local chemical action is avoided. When the circuit of the battery is closed, the hydrochlorate of ammonia is decomposed, and chloride of zinc is formed. The electro-motive force of this battery is said to be considerable, 28 elements of the Leclauché battery being said to be equal to 40 of Daniell's. Its internal (or liquid) resistance is also said to be very small.

It has been adopted by the Chemins-de-fer de l'Est, de l'Ouest, du Nord, and

de Paris, Lyons à la Mediteranée, and in the former is said to have been tried for ten months with very excellent results.

The advantages claimed for it are—absence of chemical action when the battery circuit is not complete, and consequently no waste of material; it requires little or no looking after; the cost of maintenance is small; it cannot be injured by mixing or upsetting the liquids; the battery, ready for action, may be placed in store without deterioration or loss in its component parts; and it possesses great facility for transport, without injury to the working powers.

Thomsen, Copenhagen. Polarization battery.

In the Danish section, Thomsen, of Copenhagen, exhibits a polarization battery. The construction of this battery is shown in Fig. 36. (*a*, *b*, *c*, &c.) are a series of platinum plates in diluted sulphuric acid; now, if the carbon pole of one cell of a battery be brought in contact with (*a*) and the zinc pole with (*b*), oxygen, or negative electricity, will be deposited on (*a*), and hydrogen, or positive electricity on (*b*). In Thomsen's arrangement, he places a single carbon and zinc cell in connection with a series of platinum plates, as above described, and, by means of a contact-maker, turned rapidly round, he makes contact in succession between each plate and each pole of the cell of the battery, and the result is a development of a charge of positive and negative electricity on each platinum plate; and, by connecting the two extreme platinum plates by a wire, the circuit is completed and a current passed.

The purpose of this battery is to make a single carbon and zinc cell perform the work of a great many.

Austrian War Department. Battery used with submarine mines.

The construction of an element of this battery is shown in Fig. 37; it has already been described in the account of Austrian submarine mines, at pages 65-66. The batteries are arranged in groups of 12 cells each, in wooden frames, and they are used in connection with an intensity coil for firing submarine mines, according to the system exhibited by the Austrian War Department. This is said to be a very constant battery, and it is stated that it may be used for a very considerable length of time without losing its working power to any considerable extent.

Electrical Instruments.

Siemens and Halske, Berlin. Resistance coils.

In the Prussian section, Messrs. Siemens & Halske, of Berlin, exhibit a set of resistance coils in a very compact form, with a galvanometer and Wheatstone's bridge complete, the whole in a wooden box.

The unit of resistance is Siemens's, viz.; one metre of pure mercury, of one square millimetre in section, at a temperature of 0° centigrade. The system is provided with plugs, so that any resistance required may be easily introduced at will, and the bridge itself also contains proportional coils, by the use of which very small resistances may be measured. Messrs. Siemens exhibit two sets of resistance coils, the larger capable of measuring from 1 to 10,000 units, and the smaller from 1 to 1,000. Both these instruments seem very nicely finished.

One Siemens unit of resistance = ·963 of a British Association unit; the latter is generally adopted as the standard unit in this country.

Messrs Siemens Bros., Charlton. Differential Galvanometer.

In the British section, Messrs. Siemens Brothers, of Charlton, exhibit a differential galvanometer, of peculiar construction. This instrument is the invention of C. W. Siemens, Esq., F.R.S., of the above mentioned firm, and consists of two coils of fine insulated wire, placed parallel to each other, with a magnetised needle lightly suspended between them. A movement is given to these coils by means of a micrometer screw, so that their relative position, with regard to the magnetised needle, can be altered; that is to say, one may be placed closer to or further from it, as compared with the other.

When a current of electricity passes through either of these coils, it tends to deflect the needle; and the coils being so arranged that, when equidistant from it, two equal currents passing, one through each coil, in opposite directions, shall exactly balance and produce no deflection in the needle, we have the means, by approaching one of these coils, of causing the needle to deflect, and of measuring that deflection on a scale, while at the same time we can measure the distance we have moved the coil towards the needle, to produce the deflection; this latter measurement is indicated on a scale of curved form, attached to the micrometer screw.

It is thus evident that we have the means of measuring directly the effect of a current of electricity, by comparison with that of a known current, by simply passing the former through one coil, and the latter through the other, and moving them till there is no deflection, when the relative distance, indicated on the scale, gives a comparison of the relative value of each. The advantage claimed for this instrument is the power of measuring a current of electricity by direct comparison. Resistances can also be measured by it, in a similar manner, with great facility.

Meidinger, Carlsruhe. Tangent Galvanometer.

In the Baden section, Meidinger, of Carlsruhe, exhibits a tangent galvanometer, to the needle of which is attached a long vulcanite pointer, to increase the distance from the point of suspension, and thus give more minute measurement of deflection.

This instrument has three terminal screws, which may be variously connected in circuit, to give various values to the units, expressed on the scale as follows:—

	Grammes.
With No. 1 screw each degree represents	0 0001
„ 2 „ „	0·0010
„ 3 „ „	0·0100

The principle on which the instrument is constructed has reference to the weight of hydrogen developed in an hour, the unit current producing 1° of deflection, giving one gramme of hydrogen in one hour.

Thus with No. 3 screw, the weight given is equivalent to 112 centimeters of gas, at 0° centigrade, and 700 millimetres barometric pressure.

By the simple multiplication therefore of the degrees of force, indicated in the graduated dial card, with the equivalent weight of any metal, the absolute weight of metal reduced from its solution by a given current, in one hour, is found.

The advantage claimed for this instrument is the establishment of a definite relationship between the unit of current and the unit of deflection.

Instruments for Firing Charges of Powder.

The Secretary of State for War, London Wheatstone's magnetic exploder.

We now pass on to the class of instruments applicable to the ignition of gunpowder, and other explosives, by electrical agency, and among these is exhibited, in the model barrack, attached to the British section, Wheatstone's magnetic exploder.

This instrument is the invention of Professor (now Sir Charles) Wheatstone, and is constructed on precisely similar principles to his "letter showing magneto dial telegraph" instrument, that is to say, the current is induced by the rapid revolution of an armature in front of the poles of a compound magnet, on which coils of fine insulated wire on soft iron cores have been erected.

In this instrument several compound magnets are arranged, with separate coils on each, and the induced currents, thus separately induced, are combined in one circuit, by which a series of short currents, first in one direction, and then in the opposite, of greater power than could be obtained from a single compound magnet, are circulated. The conducting wires of this combined system are led to terminals, to which the wires, in connection with the charges to be fired, can be connected, the current induced in the coils circulated, and the fuzes fired.

The instrument is provided with six touches or triggers, in connection with six terminals, to receive the conducting wires of as many charges, or groups of charges, to be fired, the circuit being completed, either through the earth with an earth plate at the instrument and charge terminals, or by a return wire, attached to a binding screw in connection with the other extremity of the fine coils of the bobbins. As long as the handle, in connection with the armature, continues to be turned round, a series of short currents, first in one direction and then in the other, continues to be induced, and when one of the triggers is put down, the circuit through the charge attached to it is completed, and the charge fired; but till the trigger is put down the circuit is not completed, and no current passes. If conducting wires be attached to each of the six binding screws, the different groups of charges in connection with them can be fired in very rapid succession, by continuing to turn the handle, and pressing down the triggers one after the other.

This instrument is intended to be used with a fuze, such as Abel's, designed to be fired by a current of electricity of high tension, and, in dry soil, as many as ten charges arranged in simple divided circuit, (see Fig. 38), may be fired practically simultaneously; in salt water not more than four similarly placed can be fired together. The current passes through that which has the least resistance first, and fires it; it then takes that which has the next least resistance, and

so on, in such rapid succession as to be practically simultaneous. The limit to the number of fuzes, that can be fired in this way, is determined by the conducting power of the earth or water surrounding the charges. As each is fired a certain amount of the current leaks away through the broken conducting wire, and completes the circuit to the earth terminal of the instrument, without passing through the other fuzes, and when the aggregate of these leaks deducts so much from the total current circulated as to deprive it of the power to fire a fuze, no further charge could be exploded. It is thus easily understood how a greater number of fuzes can be fired in dry earth than in the better conducting medium of water. The weight of this instrument is about 30 lbs.

The advantages claimed for this instrument, are portability, that it is always ready for use, and that no batteries are required.

Marcus, Vienna. Magneto-electric apparatus exhibited by Austrian War Department.

In the Austrian Military section is exhibited a magneto induction apparatus, designed for firing charges of powder, by Marcus of Vienna. The general arrangement of this instrument is shown in Fig. 39; (*n*, *s*) is a large permanent magnet, between the poles of which a soft iron armature (*a*), in connection with a very long coil of fine insulated wire (*b*) is placed.

The whole is enclosed in an ebonite box (*d*), the extremities of the coils of wire being led to binding screws (*c*, *c*), to which the conducting wires from the charge, to complete the circuit are attached. A handle (*e*), in connection with the armature, gives the power of turning it, within the limits allowed by the horns of the magnet, and it (the armature) is held in the position of breaking contact with those poles by a strong spring.

When the handle (*e*) is turned, the armature is brought into the position of contact with the poles of the magnet, and is arranged to be held there by a stud (*f*), in connection with the trigger, which keeps it in that position. As soon as the connecting wires of the charge have been attached to the terminals (*c*, *c*), the stud (*f*) is pressed down by hand, the spring set in action, the contact of the armature (*a*), with the poles (*n*, *s*) of the magnet, broken and a positive magneto-electrical current, induced in the coil, circulated through the system, by which current the fuze is fired.

Several sizes of this instrument are exhibited weighing about 2 lbs., 10 lbs., 20 lbs., and 30 lbs. respectively, and capable, according to size, of firing one or more fuzes in simple continuous circuit.

It is stated that as many as six fuzes of Von Ebner's pattern, which possess a high electrical resistance, have been fired simultaneously, with the largest form of instrument exhibited. A greater quantity of electricity is obtained by this system than by Professor Wheatstone's; but once discharged, the handle must be again turned, and the new conducting wires connected with the terminals before a second group of charges could be fired; whereas in Wheatstone's instrument, it is only necessary to press down a series of triggers, while circulating a series of short currents by turning the handle in connection with the armatures. The greater quantity of electricity seems to be produced

by the very great length of insulated wire in the coil connected with the armature.

The advantages claimed for this instrument are similar to those for Professor Wheatstone's.

Marcus, Vienna. Magneto electric apparatus, with revolving bobbins Exhibited by Austrian War Department.

In the Austrian military section is also exhibited a magneto induction apparatus, designed by Marcus, of Vienna, for firing charges of powder. The arrangements in this instrument are very similar to those of Marcus's magneto dial telegraph instrument; that is to say the coils, on soft iron cores, are made to revolve with the armature in front of the poles of a permanent magnet, by which means a rapid succession of instantaneous currents, of high tension, is circulated.

This approaches more to Wheatstone's form than the other, and its advantages are much the same.

Austrian War Department. Glass frictional machines.

In the Austrian military section is exhibited a large glass frictional electric apparatus for firing charges of powder. This machine is about 4 feet high, and of the ordinary form adapted for this class of instrument. The electricity is generated by the friction of silk cushions, amalgamated with mercury, tin, zinc, and a little grease, upon a pair of glass discs, placed parallel to each other, so as to be turned by means of a handle. It is collected in a large Leyden jar, and discharged through the circuit by connecting it, in the usual manner, between the inner and outer armatures of that jar.

The charge capable of being collected by the agency of this large machine is very considerable. It was designed for use, in a stationary position, in connection with a system of submarine mines, to be fired at will. A similar portable apparatus, fitted in a box 2 ft. long, 1 ft. broad, and 1 ft. 6 in. high, as shewn in Fig. 40, was constructed for field service, but in consequence of the danger of breakage in transit, it has given place to the less fragile ebonite frictional machine for that purpose.

The box is fitted with legs, which double up, when it is required to be moved.

Von Ebner's frictional electrical machine. Exhibited by the Austrian War Department.

In the Austrian military section is exhibited an ebonite frictional electrical machine, for mining purposes, designed by Baron Von Ebner, Colonel of the Austrian Engineers. The principles of this apparatus are precisely the same as those of the glass frictional machines.

The glass discs are replaced by ebonite with leather cushions, and the Leyden jar by a condenser, formed of two sheets of tin foil, insulated from each other by sheets of india-rubber, and rolled into a compact cylindrical form to fit into a box below the discs. One of these sheets of tin foil corresponds to the inner armature of the Leyden jar, in which the charge is collected, and the other corresponds to the outer armature.

Studs, in connection with these sheets of tin foil, are carried through the insulation, by which the condenser is first charged, and the charge subsequently

passed through the circuit, by connection made by simple mechanical means. This instrument is capable of firing a very large number of fuzes, in simple continuous circuit; as many as 60 Abel's fuzes have been fired simultaneously by this apparatus. The portable apparatus is supplied with legs for use in the field, the top has a moveable cover, to protect it from dust, when travelling; and when in use small particles of dust are attracted by the ebonite, when rubbed, which would soon dirty the discs and deteriorate the instrument; it is very necessary to keep it clean, and for this purpose it should be well rubbed occasionally with flannel and turpentine; the cushions too must be kept well amalgamated. It is fitted with straps to be carried on the back like a knapsack. This instrument possesses great portability, and with ordinary care, it has proved itself a very efficient arrangement for mining purposes.

It is a great advantage being able to dispense with batteries. In moist or damp air it is necessary to fire the mines in circuit, directly the condenser has been charged, as the electricity will gradually leak away, and a loss of power would be experienced, if it were left even for a comparatively short space of time. In dry air this is not so necessary, though it is always desirable to fire directly the condenser has been charged. Under favourable circumstances an Abel's fuze has been fired, with one of these instruments, four hours after it was charged; there is however great uncertainty as to the time it can hold its charge, or rather hold enough of it to fire a fuze; there is no doubt that, from the moment the condenser is charged, the electricity begins to leak away, and this leakage is much more rapid, when the air is charged with moisture, than when it is dry. Great care must be taken in using this instrument, to prevent accidents by firing charges not connected with it, by induction, to which danger it is peculiarly liable.

This instrument, as arranged for field service, weighs about 30 lbs., including the legs, and its cost is £16.

Siemens and Halske, Berlin. Dynamo-electrical machine.

In the Prussian section, Messrs. Siemens and Halske, of Berlin, exhibit an instrument called a dynamo-electrical machine. This instrument is very similar in its arrangements to any magneto electrical apparatus of ordinary construction, but in it the permanent magnet is replaced by a piece of soft iron (*c*) Fig. 41, round which a coil of fine insulated wire is wound, as at (*a*, *a*); (*b*) is a Siemens's armature of soft iron, on which a coil, in metallic connection with the coil (*a*), is wound. When this armature is made to revolve rapidly, the residual magnetism, in the horseshoe-formed piece of soft iron (*c*), induces a series of currents of electricity in the coils of the armature; or if there is absolutely no residual magnetism in (*c*) it is only necessary to touch it with a permanent magnet for a moment, when beginning to move the armature (*b*). The currents thus induced in the coils of (*b*) circulate through the coils (*a*, *a*) and increase the magnetism, which in its turn reacts on the coils (*b*), and induces a stronger series of currents. In this way the one may be made to react on the other, till (*c*) becomes a powerful electro-magnet, and a very considerable current is induced in the coils, (this occurs after a very few turns,

and it may be utilised in any way, of a similar nature to that for which the ordinary current, produced by a magneto-electrical machine, is available, by simply discharging it through any circuit required.

This property of soft iron was discovered by Dr. Werner Siemens, of Berlin; he states that there is always sufficient residual magnetism in the soft iron, to induce a small current in the coils, and in the instruments exhibited it is evident that the reaction of magnetism on currents, and *vice versa*, increases it very rapidly.

Two instruments of this nature are exhibited, a large one, producing a very powerful current and a smaller one in a wooden box, weighing about 15 lbs., and intended for mining purposes. The price of this latter is £16. It is arranged that the circuit, through the charges to be fired, shall be mechanically made and broken at intervals, so that at the time it is broken, the reaction already described may take place, and the currents stored up, as it were, in the coils; and when the circuit is closed, it may be discharged, with the utmost accumulation of force through the fuzes.

The advantage claimed for this instrument, over magneto-electrical machines of ordinary form, is the absence of permanent magnets, on which the efficiency of the latter depends. Should the permanent magnets, by any accident become de-magnetised, or even should their magnetism be weakened, the instrument is deteriorated or destroyed; no such accident can take place with the dynamo-electrical machine.

Ladd. Beak Street, London. Dynamo-electrical machine.

In the British section, Mr. Ladd, of Beak Street, London, exhibits a dynamo-electrical machine. The principle of this instrument is precisely the same as that of Siemens, but the arrangements differ, inasmuch as Ladd employs two armatures, one to create the electro-magnet, and the other to produce a current therefrom, with which to perform any work required. Fig. 42 gives the general arrangements of the instrument: (*a*, *a*) are two soft iron bars, round which coils of fine insulated wire (*b*, *b*) are wound, in metallic connection, with the coil of an armature (*c*), revolving between their extremities. When the armature (*c*) is made to revolve, exactly the same effect is produced as in Siemens' instrument, and the result is that the two bars (*a*, *a*) become very powerful electro-magnets; now instead of discharging the current thus induced through his working circuit, to fire fuzes, or perform any other work which necessitates the beginning again, as it were, to create a new current, Mr. Ladd introduces a second armature (*d*), revolving between the soft iron bars, from which he obtains his working current; the magnetism of the bars is thus always kept up. The residual magnetism of the system is always sufficient to commence the action described, except, perhaps, when the instrument has just been made, and has never been used, when it is necessary to touch the bars with a permanent magnet, or pass a voltaic current through the coils for an instant, to obtain the magnetism required. The instrument exhibited was only 24 in. long, 12 in. broad, and 7 in. thick, but the effects produced by it, when worked by a steam engine of one horse power, were very

great, and would seem to augur well for the future of this system, which Mr. Ladd proposes to apply to the production of an electric light for light-house purposes.

The advantages claimed for it are the absence of permanent magnets in the system, and the power of keeping up the force of the electro-magnets without diminution, by the discharge, through the working circuit, of the current producing them.

Machine for Registering Level of Water.

Messrs. Siemens and Halske, Berlin. Machine for registering the level of water by electricity.

In the Prussian section, Messrs. Siemens and Halske, of Berlin, exhibited a magneto-electrical apparatus, for registering the level of the water in a tank, when the cistern is not easy of access. It consists of a group of permanent magnets, between the poles of which an armature, carrying a fine insulated wire, is placed. The movement of this armature is caused by the rising and falling of a float in the water, in connection with a counterbalancing weight, attached to a line, passing over a pulley, acting on it. It is thus easily seen, that when the weight descends, consequent on the rising of the float, the armature will be turned in one direction, whereas if it ascends, indicating a diminution in the depth of the water, the armature will be turned in the opposite direction; in the one case a series of currents, positive, negative, and so on, while in the other, a series of currents, negative, positive, and so on, will be induced; these are made to circulate through a small electro-magnet, with a polarized keeper working an escapement, in connection with a small dial, the hand of which is therefore moved forwards or backwards, as the water rises or falls, and its level is always to be seen at a glance on the register.

Electro-Magnet.

Large electro-magnet in the Austrian section

In the Austrian section is exhibited an electro-magnet of large dimensions, the conductor round the core of which is a flat ribbon instead of wire. The object sought in this arrangement is close stowage, so that a much greater length of coil may be placed in the same space.

In concluding this description, I must bear testimony to the very great kindness of Robert Sabine, Esq., of the firm of Messrs. Siemens, of Charlton and Berlin, who took an immense deal of trouble in explaining to me many points in connection with the construction of several of the instruments described. Without his assistance I should have had great difficulty in discovering several important inventions as, at the time I arrived in Paris, the prizes had been awarded, and many of the exhibitors had left, and there was frequently no one to explain some of the most essential points, without which the most minute description, as regards external appearances, would have been worthless.

The instruments described form but a small portion of those exhibited, but I have endeavoured to pick out those most worthy of notice, or in which some novelty in construction or working, appeared to exist.

R. H. S.

IV.—Description of Naval and Military Visual Signalling Apparatus in the Paris Exhibition of 1867.—(Pl. IV and V).

By CAPTAIN R. H. STOTHERD, R.E.

As a powerful adjunct to, and extension of, a military electric telegraphic system, visual signals appear to be destined to play a very important part in modern warfare, and they are especially applicable to operations where a combined naval and military force is employed. The well-known system of communication between ships at sea, by means of flags, has been in operation from time immemorial; and in the late American war, visual signals of various kinds were used, with very considerable success, for purposes of communication between bodies of troops engaged in military operations; in fact, the attention of naval and military officers, generally, has been turned lately to the development of a simple system, fulfilling the conditions required, and we find two such systems shown in the Paris Exhibition of 1867, viz.: Colomb and Bolton's flashing system in the British, and Von Ebner's system in the Austrian section. The details of these may be described as follows:—

In the Admiralty annex of the British section of the Exhibition, several forms of visual signalling apparatus are exhibited by Commander Colomb, R.N., and Captain Bolton, 12th Regiment, designed for communication between vessels at sea; between ships and bodies of troops engaged in combined naval and military operations; and between detached bodies of troops in motion on land. The apparatus is available by day or night under every variety of circumstances that may occur.

Day Signalling.

Colomb's shutter apparatus.

Commander Colomb's shutter apparatus is shown in Fig. 1, Pl. IV. It consists of two upright posts connected by cross pieces at top and bottom, and forming a frame, in which is placed a series of broad flat sheet-iron plates, moveable into a horizontal or vertical position, by means of a pivot in the centre of each, in connection with a lever (*c*). When the shutters lie horizontally, as represented at (*a*), an observer sees nothing, as at a short distance, the slight skeleton frame is invisible; when they lie vertically, as at (*b*), a very large surface comes into view; and signalling is carried on by long or short exposures of this surface, by means of a series of numbers in connection with a code or letters, adapted for use with all the instruments exhibited, as will be hereafter described.

This apparatus is designed for permanent stations on shore, and, when necessary, would be mounted on a pivot, so as to turn in any direction required. A modification of the instrument may be used for ship purposes. It may be made of any size, suited to the distances through which signals are to be transmitted. An apparatus, exposing a surface of 72 square feet, as at (*b*), gives a range of 15 miles in clear weather.

Signalling may be carried on with it with great rapidity, as the appearances and disappearances may be produced 100 times in a minute, with ease.

If the apparatus is used against a dark background the shutters should be kept whitewashed and the framework painted black; if against a light background the shutters should, on the contrary, be painted black, and the framework white.

Colomb's drum or double cone. Commander Colomb also exhibits a double cone or drum apparatus for day signalling. This is of two sizes and is represented in Figs. 2 and 3. Fig. 2 represents the larger size, which is arranged to be hoisted, where most convenient, about 20 feet above the deck of a ship, when used for naval purposes, a height which has been found sufficient for the most distant signals; it is worked by hand, and is self collapsing, that is to say, the weight of the upper half is so arranged as to cause it to fall, when the line (*c*) is slackened, and, in falling, it is made to draw up the lower portion.

The drum, as extended, is shown at (*a*), this corresponds to an exposure of the shutter apparatus, the drum collapsed is shown at (*b*). Signals are transmitted by long and short exposures, as will be hereafter described.

Fig. 3 shows the smaller and more portable apparatus, for boat service. It consists of a pair of collapsing cones, on a staff, fitted on a principle resembling the opening and closing of an umbrella; (*a*) shows the apparatus closed, and (*b*) open, the latter representing an exposure as already described. In working, the closing line (*c*) should be held in the left hand, the opening line (*d*) in the right hand.

For convenience, it is desirable to ship the staff in a socket while signalling, and it is made to fit that designed for the reception, on board ship, of the night signal lamp to be hereafter described.

By it signals at short distances can be sent from ship to ship, but it is specially designed for boat service, where portability is an object. The double drum, 4 ft. 6 in. in height, and with the same diameter, can be used for signalling, in clear weather, up to 11 miles; the double cone for boat signalling, 3 ft. in height and 3 ft. in breadth, can be used at distances within 5 or 6 miles, under favourable circumstances. Cones possess great advantages for naval signalling, from the fact that by them a message can be sent in all directions at once.

Colomb's disc apparatus. Where great portability is desirable, an apparatus, as represented in Fig. 4, is used. It consists of a light disc 2 ft. 6 in., in diameter, black on one side and white on the other, attached to a handle, having a cross piece at one extremity, to give leverage for turning it, as well as to enable the man working it to keep the edge or face, as required, fairly presented to the observer. (*a*) represents the disc on edge, or invisible. (*b*)

represents an exposure as already described. To transmit signals, the apparatus is held as in the figure, the cross of the handle being in the right hand, and the left grasping a piece of tubing, which forms a bearing through which the handle turns.

The range of this apparatus is about three miles in favourable weather. With a dark background the white side is presented to the observer; with a light background the black is used.

Colomb's Fog Horn, for signalling purposes.

For cases where visual signals cannot be used—as, for example, during a fog, or where an object intervenes—Commander Colomb has designed a fog horn, which he exhibits. It is extremely portable, weighing only 2 lbs. Signals are transmitted by it up to a distance of about $1\frac{1}{2}$ miles, in still weather, by long and short sounds.

No skill is required, as in the bugle or trumpet, in blowing this instrument, the sound being produced by a tongue inserted in proper position in the mouth piece.

Night Signalling.

Colomb's sea service night signal lamp

For night signalling, Commander Colomb exhibits a lamp, Fig. 5, which contains a powerful light, the rays of which are collected into a horizontal plane, by means of a lens. Over this light is a semi-cylindrical shade, which falls by its own weight and completely obscures it; when raised it completely exposes it, and the means are thus obtained of sending a series of flashes, of long or short duration, which correspond to the long or short exposures of the day apparatus already described. Attached to this instrument is a signal box, which contains a barrel or cylinder, turned by a handle (*d*). The surface of this barrel is fitted with four series of projections, consisting of pins and bars, corresponding to the long and short flashes, representing the numbers from 1 to 10 used in signalling, as will be hereafter explained: on a brass plate running along the side of this drum, are arranged the numbers corresponding to the pins and bars thereon, and in connection with each series an arm so fitted with a spring, that when it is placed opposite any required number, it comes in contact with the pins and bars on the barrel, and by means of a crank draws down the string (*c*), and raises the shade in front of the light for a long interval, if the arm is in contact with the long projection or bar, and for a short interval, if it is in connection with a short projection or pin; and the required series of long and short flashes representing any number required, is thus transmitted mechanically. A fifth arm is placed at one end of the plate, in connection with a fifth series of bars and pins, representing certain auxiliary signs required.

Between each series of figures or signs a certain interval is allowed, by the arrangement of the pins and bars on the barrel, so that the numbers transmitted in succession may be perfectly distinct, for each revolution of the barrel, and between the end of the fourth series and commencement of the first, an interval amounting to one fourth of the whole circumference is allowed. The object of

these intervals is to separate the figures of each particular group one from the other, and as every signal is continuously repeated till understood and answered, the long interval at the end is required to show that the series has terminated and is about to re-commence.

In signalling, it is only necessary to put the keys or bars, already described, into the slots, corresponding to any required series of figures to be transmitted, and then to turn the handle continuously to produce a recurring series of flashes, corresponding to the setting of the instrument, with unfailing accuracy. In any system of signalling by means of the long and short exposure of a light, it is of very great importance that the shade should work so as to expose, or cut that light off sharply in contradistinction to gradually, and this apparatus works remarkably well in this essential particular.

The lamp is hung on a gibbet, which slips into a socket screwed on to the hammock rail, its upper surface being level with the top; two brackets are fixed below each socket, at a convenient height above the deck, for working the barrel when hooked to them. They should be placed at equal distances below the socket.

Colomb's signalling lamp for boat service.

Fig. 6 shows a lamp for boat service, the principles of which are precisely the same as those of the larger pattern: it consists of a light with reflector and lens, combined with a signal box in a very portable form.

Bolton's lime light signalling apparatus.

In the Admiralty annex of the British section, Captain Bolton, of the 12th Regiment, exhibits his lime light apparatus for signalling purposes.

The instrument, which is a very ingenious adaptation of the Drummond light, consists of a combination of lenses for emitting parallel rays of light, mounted in a metal cell, with a screw adjustment to enable the lenses to be fitted at a proper distance from the light, or removed when not required in thick or foggy weather; behind the lens an improved safety jet is placed, with a regulator for burning hydrogen, (polished bright for identification), and for oxygen gas, (coloured black). To produce the light a mixture of oxygen and hydrogen gas, in a state of ignition, is thrown on a pencil of quick lime. The admixture of the gases does not take place until they are simultaneously thrown on the lime, thus effectually preventing all possibility of an explosion. Immediately behind the jet is the lime holder, with a screw adjustment, whereby the pencil may be moved forward occasionally as the lime burns away. The result of the combination thus provided is a very brilliant light, by means of which signals may be transmitted to distances of 25 miles, in favourable weather.

Signals with these instruments are transmitted by long and short exposures of the light, and for this purpose a moveable disc is so arranged as completely to obscure the light when in its ordinary position. To this disc is attached a lever, worked by means of a finger key, the depression of which acts on the disc, and exposes the light, for a long or short interval, as required; on removal of the finger, the lever and disc attached are sharply drawn up by a spring, and the

light completely obscured. The instrument is mounted on a metal base, with joints for horizontal and vertical motions, and the means of clamping the same in position.

The whole is enclosed in a metal lantern, screwed to a brass frame with a mahogany base, fitted with a drop screen, to protect the eyes of the operator when signalling, and provided with two doors, with strap hinges for enclosing the ends.

A capstan screw is provided for the purpose of attaching the whole apparatus to the carrying case, when in use. A mica cover is fitted over the burner, and the metal ventilating top is provided with sights placed parallel to the line of the light, to direct it with precision to a distant station.

The burner. The burner consists of two tubes or stop cocks, one for oxygen, the other for hydrogen, fixed with a brass bush under the plate, the end of the tubes corresponding with separate passages through the upright pipe and terminating in two angular jets, through which the gases make their exit, preventing thereby the possibility of their burning till they reach the open air, and the consequent chance of an explosion.

Into the base of the brass plate are inserted the burner and lime-holder, moving horizontally by means of a screw, by which they are placed in position and there retained.

The lime-holder is provided with a carrier for the purpose of regulating its distance from the jet. Hydrogen and oxygen gases being of different specific gravities, it has been found necessary to throw them from the jets at different angles, to insure perfect combustion, this has been provided for in the construction of the instrument, and, as it is of importance that the exact angles should always be retained, an apparatus for drilling them has been specially designed by the maker for this purpose.

Carrying case. The whole apparatus packs in a rectangular wooden case, see Fig. 7, Pl. V., which also forms a stand when arranged for signalling. Fig. 8 shows one side of this stand, and Fig. 9 the other, with the lamp screwed on, as already described, and the several stores, &c. arranged round them. This case consists of four compartments, the two sides for the gas and pressure bags, with doors to fall down, and forms a base, on which they rest when in use.

Gas bags. The gas bags are made of strong indian rubber cloth, and designed to hold oxygen; the pressure bags are simply made of canvas, and are intended to be filled with earth or sand, and placed over the gas bags, to force the oxygen into the tubes at a sufficient and uniform rate. A stick passes through the centre of both bags, and is attached to the door, to prevent them falling off when in use. The front compartment is fitted with three drawers to contain tools, lime pencils, &c., see Fig. 9, under which is a space for a tray of oxygen mixture, bottles, gas stove, retort, &c.; above them are a small pair of bellows and several stop cocks, connected with the pipes supplying gases to the intrument. The opposite compartment, see Fig. 8, is lined with lead, and is fitted with a copper hydrogen generator, three gutta percha covered glass bottles, to hold sulphuric acid, one wash bottle for hydrogen gas, and two con-

nections, one from the generator to the wash bottle, the other to the gas stove, when required to generate oxygen.

Oxygen generator.

The oxygen generator is shewn in Fig. 10; it is made of copper, and the top unscrews to admit the mixture, which consists of 6 of chlorate of potash, and 1 of peroxide of manganese; the cap is then screwed down and it is placed on a slow fire, and when the steam consequent on any slight moisture has evaporated, it is connected through the purifier with the gas bag, and the latter filled. The purifier consists of a zinc vessel filled with water, through which the gas is passed, which cools it and deprives it of any condensable or soluble impurities, sufficiently to make it ready for use.

Hydrogen generator.

The hydrogen generator is composed of copper, and of the form shown in section, in Fig. 11; (*z*) is a compartment, which should be filled about one-third with scrap zinc, (granulated zinc is very good for this purpose), (*h*) is an opening through which the zinc is introduced, which is tightly secured with a screw arrangement; (*b*) is a perforated bottom through which liquid, placed in the compartment (*w*) is admitted through the passage (*o*), which latter extends completely across the generator to the zinc compartment (*z*). A mixture of diluted sulphuric acid, in the proportion of 1 of acid to 20 of water,* having been introduced into the compartment (*w*) through the opening in its top, it passes through and acts upon the zinc, in compartment (*z*), generating hydrogen gas, which is passed through the stop cock in the top of (*z*), and conducted to the washing bottle, from which it passes ready for use to the hydrogen jet. When the hydrogen is not being rapidly used, or when there is a temporary cessation of signalling, the gas generated in the compartment (*z*) drives back the diluted sulphuric acid, and the action on the zinc ceases: there is thus no loss of gas, during a pause in signalling.

When no ordinary fire is at hand, oxygen may be generated over a small gas stove, provided for the purpose, the hydrogen previously obtained being used as fuel. When both the gases have been provided, it only remains to conduct them in proper proportions to the point of ignition, for which purpose the apparatus is fitted with a simple arrangement of tubes and stop cocks. The weight of each case of this apparatus packed complete is 1 cwt. 3 qrs.

Bolton's oxy-calcium light.

Another form of light for signalling purposes is exhibited by Captain Bolton. This he calls his oxy-calcium light. It is a modification of the former one, and consists of a spirit lamp, in combination with which, a jet of oxygen is thrown on a pencil of quick-lime. In this arrangement it only becomes necessary to provide oxygen; the requisite stores for making hydrogen are, therefore, dispensed with. This renders the instrument much more portable, and in all essentials simpler. Its weight complete, with box for carrying every requisite for making oxygen gas, is about 1 cwt. It can be used for signalling up to a distance of 12 miles in favourable weather.

* The proportion of sulphuric acid to water depends on the strength and purity of the acid, and where the latter is not of first-rate quality a larger proportion is used.

Bolton's magnesium light apparatus.

Captain Bolton also exhibits an apparatus designed for signalling with a light produced by the combustion of magnesium wire. It consists of an arrangement of clock-work for drawing out the wire at a uniform rate, by means of a pair of feeding rollers which are contained within a brass cylinder, $1\frac{3}{4}$ in. long, and $1\frac{1}{2}$ in. in diameter, through which it is by this means passed to the point of ignition, which is exactly in the focus of a lense arranged to concentrate the rays into the line required. On this brass cylinder a certain proportion of the fumes produced by the combustion of the magnesium are condensed; these remain for a time in an incandescent state, and thus add to the brilliancy of the light, and by heating the magnesium wire render it more easy of combustion.

A pair of nippers, kept in motion by the clock-work, cuts off at intervals the ash produced by combustion, and allows it to drop into a receptical provided for it. This is necessary to prevent its weight from accumulating on and breaking the wire at the point of combustion, and thus putting out the light. Fig. 12, shows the apparatus mounted on its legs and ready for use; (*a*) is the reel of wire to be paid out; (*b*) the lens, covered by a movable disc in contact with its surface and obscuring the light; the side of the disc next the lens is covered with wash leather, which rubs off any condensation thereon of the fumes at each exposure of the light. The disc is in connection with a finger key, by the depression of which it is drawn aside, and the light exposed for a long or short interval, as required.

A chimney (*c*) serves to carry off the greater portion of the fumes produced by combustion. The lens used is a double plano convex. Fig. 13 shows the apparatus packed for transport; the lamp and clock-work in its wooden case, in a leather cover, with carrying straps, which also contains a few tools, &c., required for the instrument.

A bell is rung by the clock-work five minutes before it is completely run down, to give notice that it is necessary to wind it up.

The weight of this instrument packed for transport is about 35 lbs.; and this combined with the absence of all chemical or other stores difficult of carriage, gives it a considerable advantage for military purposes. The cost of signalling with it would be about 2s. an hour, and it can work through a distance of about 15 miles in favourable weather.

It cannot as yet be said to be a perfect instrument; it has, however, been but recently invented, and it is to be hoped, that one or two mechanical defects of a trifling nature* may be overcome, which, being done, it would be a most efficient military signalling instrument.

* The defects are chiefly in the manufacture of the magnesium wire, impurities occasionally existing in it which, on arrival at the point of ignition, put out the light; slight inequalities or knots also, formed at the junction of two lengths, are liable to catch in the clock-work (feeding rollers) and, by stopping the supply of wire, also put out the light. The manufacturers have turned their attention to the improvement of the magnesium wire in these respects, and state that there is every prospect of obviating these difficulties.

The following list shows, in a comprehensive form, the weight and price of the several articles exhibited.

	Weight.	£	s.	d.	
Shutter apparatus *		0	6	8	per square foot.
Double drum, 3 ft. by 3 ft.	26 lbs. ..	5	0	0	each.
Double cone, 3 ft. by 3 ft.......	12 lbs. ..	7	0	0	„
Disc, in diameter, 2 ft. 6 in......	5 lbs. ..	1	5	0	„
Fog horn, with spare tongue ..	2 lbs. ..	0	17	6	„
Naval signal lamp, large, with signal box, complete	80 lbs. ..	31	6	0	„
Ditto, boat size	24 lbs. ..	22	10	0	„
Lime light apparatus, with case complete	1cwt. 3 qrs.	45	0	0	„
Oxy-calcium light apparatus, with case complete.........	1 cwt. ..	30	0	0	„
Magnesium light apparatus, complete	35 lbs. ...	20	0	0	„

Mode of signalling. The mode of signalling with the whole of the apparatus exhibited is by an alphabet and numerals, on what is known as the flashing system. In the following table, a short flash or dot, represented thus (-), indicates a flash or exposure of half a second; a dash, represented thus (—), a flash or exposure of $1\frac{1}{2}$ seconds: this is the time adopted, (after numerous experiments), by Commander Colomb, for Naval signalling, and is specially applicable to code work.

Numerals.

1.	-	6.	—
2.	- -	7.	- —
3.	- - -	8.	— -
4.	- - - -	9.	- - —
5.	- - - - -	0.	— - -

Auxiliary Signs.

Compass	— - —
Pendants	— - - —
Numeral	— - - - -
Special	- — - -
Horary	- - — -
Negative	— - - -
List of Navy	- — -
Alphabetical	— —
Interrogative	- - - —
General Answer......	— - — - — - &c.,

(a continued succession of long and short flashes.)

The above numbers and auxiliary signs may be made mechanically by the signal-box already described.

* Weight according to size and construction of outer frame, which must be adapted to the particular position required.

The three following signs are always to be made by hand:

Spelling .... - — — -
Preparative .... - - - - - - - &c.
(a continued succession of short flashes.)
Stop .... — — — — — &c.
(a continued succession of long flashes.)

The Naval Alphabet.

		A.5 - - - - -		
B.6 —	C.7 - —	D.8 — -	E.9 - - —	F.10 - — - -
G.11 - -	H.12 - - -	I.13 - - - -	J.14 - - - - -	K.15 - - - - - -
L.16 - —	M.17 - - —	N.18 - — -	O.19 - - - —	P.20 - - — - -
Q.21 - - -	R.22 - - - -	S.23 - - - - -	T.24 - - - - - -	U.25 - - - - - - -
V.26 - - —	W.27 - - - —	X.28 - - — -	Y.29 - - - - —	Z.30 - - - — - -

The compass and pendant signs refer to distinguishing signals used by the Navy, the former having reference to a special code.

The numeral sign denotes that the figures following it are expressive of number, without reference to the code.

The special sign refers to the special tables of the vocabulary signal book.

The horary sign is used with numbers to express hours and minutes in the horary table used in the Royal Navy.

The interrogative sign denotes that what follows is to be read in an interrogative sense.

The negative sign denotes that what follows is to be read in a negative sense.

The List of Navy signs has reference to the signal numbers of Her Majesty's ships.

The Alphabetical sign is used with the alphabet numbers in the table, when it becomes necessary to spell a word.

The General Answer sign is used to acknowledge all signals as soon as they have been clearly made out.

The Spelling sign is used when the whole message is to be sent alphabetically.

The Preparative sign is used to attract attention before a signal is made, but it is not usually necessary.

The Stop is used to denote the conclusion of a signal, or of a word in spelling.

This method of signalling, with its special arrangements, has been designed for communicating between ships at sea, or between ships and troops on shore; but in the latter case only, the distinguishing signs referring to particular circumstances of the case would be required. It has been adopted into the service of the Royal Navy. The whole of the apparatus can be used with it for signalling purposes, but it is specially adapted for the Navy, where great speed is not required, and where, indeed, in many cases, it would be objectionable.

Captain Bolton's lime, oxy-calcium and magnesium instruments have been also very successfully used with the ordinary Morse telegraph alphabet; in this manner messages may be sent at the rate of as much as twenty words a minute, and an average of ten to twelve can be easily attained by an expert telegrapher. This requires, however, a thoroughly trained man, whereas Commander Colomb's signal-box can be used by any intelligent man without much training.

The following is the Morse telegraph alphabet, which, like that just described, is composed of a series of dots and dashes, which are transmitted by long and short exposure of the light.

A.	- — *ä (æ)* - — - —	P.	- — — -
B.	— - - -	Q.	— — - —
C.	— - — -	R.	- — -
D.	— - -	S.	- - -
E.	-	T.	—
F.	- - — -	U.	- - — *ü (ue)* - - — —
G.	— — -	V.	- - - —
H.	- - - -	W.	- — —
I.	- -	X.	— - - —
J.	- — — —	Y.	— - — —
K.	— - —	Z.	— — - -
L.	- — - -	CH.	— — — —
M.	— —	CH.	must always be sent thus (— — — —) and never as separate letters
N.	— -		
O.	— — — *ö (œ)* — — — -		

Additional Signals.

T.	Understood	—
I.	Not understood	- -
E.	Comma	-
SQ.	Full stop	- - - — — - —
MQ.	Wait	— — — — - —
GQ.	Fresh paragraph	— — - — — - —
PP.	Parenthesis	- — — - - — — -

CC.	Inverted Commas (" ")	— - — - — - — -
LL.	Underlined	- — - - - — - -
DQ.	End of address	— - - — — - —
M M.	Instructions after message.	— — — —
PQ.	End of message..........	- — — - — — - —
Correction (in sending)..........		- - - - - - - - - - &c.
R.R.	All right	- — - - — -
IMI.	Repeat or query (?)	- - — — - -

Numerals.

1	- — — — —
2	- - — — —
3	- - - — —
4	- - - - —
5	- - - - -
6	— - - - -
7	— — - - -
8	— — — - -
9	— — — — -
0	— — — — —

Austrian Military Visual Signalling Apparatus.

Austrian signalling apparatus.

In the Austrian military section of the exhibition, is shown the method adopted in their service for communicating between the several parts of a fortress or with an army in the field, by means of visual signals. The following description is extracted from the account of objects exhibited, published by the Austrian military commission :

"This telegraphic apparatus is used in our fortresses in consequence of its simplicity and moderate price. The alphabet is formed of three elementary signals, given during the day by three discs, and at night by three lamps. The size of the apparatus is regulated by the distance to which it is necessary to transmit signals. Telescopes are used in reading a message, cover being constructed in the vicinity of the signal staff for this purpose. This system is also used with an army in the field, and the mode of working is shown by two drawings. A simple baggage wagon, drawn by four horses, as in the drawing exhibited, is sufficient to carry the complete apparatus for a signal station."

The apparatus, which has been designed by Baron Von Ebner, Colonel of the Austrian Imperial Corps of Engineers, is shown in the accompanying sketches.

Day Signalling Apparatus.

The day signalling apparatus may be seen in Fig 14. It consists of a pole about 20 ft. long, with a cross arm, about 2 ft. 6 in. from the top, and at each extremity of the cross thus formed is placed a disc, about 1 ft. in diameter, coloured white and red, as sketched. These discs are made of several sizes, ac-

cording to the distance to which it is required to transmit signals; but that exhibited, as above described, shows the general proportion of the several parts; with larger discs, the arms would be made proportionately longer.

Fig. 14 shows an exposure of the discs, represented on edge, in Fig. 15, and the alphabet is composed of a series of long and short exposures of the two lower ones, and of all three simultaneously, as will be hereafter described. Two levers (*a*, *a*) Fig. 16 in connection with two rods (*b*, *b*) are arranged to produce the required motion of the discs. One of the arms is in connection with the two lower discs, and is usually held in the right hand while signalling; the other gives motion to the three discs simultaneously, and is usually held in the left hand. In the field apparatus exhibited, the pole is supported by three wooden struts, (*c*, *c*, *c*), one of which is arranged to act as a ladder, giving access to the upper portion. In a permanent position, where it is necessary to use an apparatus to signal in several directions, it would be arranged to turn on a pivot. In the field a tent is pitched over the supports (*c*, *c*, *c*) and round the central pole, to which latter it is attached, to give cover to the men using telescopes, writing messages, or transmitting signals, by working the levers (*a*, *a*).

Night Signalling Apparatus.

For night signalling, three lamps with reflectors are placed upon small stands in rear of the discs already described, and signals are transmitted by exposures of these lights, as shown in Fig 17, precisely corresponding to the exposures of the discs in day signalling; when the latter are in a vertical position, as shown in Fig. 14, the lights will be completely obscured; when in a horizontal position, as in Fig. 17, the lights will be exposed. The motions for this purpose are given by the levers (*a*, *a*) as already described.

In transmitting a message, the words are spelt, or figures sent, by the following combination, in which (.) denotes a short exposure of the two lower discs or lights; (—) a longer exposure of the same; and (.·.) an exposure of all three simultaneously.

a	— .	*d, t*	— —
b, p	— — .	*e*	.
o	— . .	*g*	. . .
h, ch	— .·.	*r*	. —
i, j	. .	*s*	. .·.
k, q	— .·. .	*u*	.·. —
l	.·. .	*v, f*	. .·. .
m	. — .	*w*	. . .·. .
n	—	*z*	.·. — .

Figures.

1	.	6	. .·.
2	—	7	— .
3	. .	8	— .·.
4	— —	9	.·. .
5	. —	0	.·. —

Call signal or stop .·. for ten seconds .. (Aufrufschluss)
End of word .·. for one second .... (Wort pause)
Error „ .·. .·. .·. .... (Irrung)
Figure signal . — .·. .... (Zahl signal)
Interrogation or dash — — — ....(Bruch strich)
Interval between each element, half a second.

The signals or combinations are used to form the letters or figures in a very similar manner to those already described, as adapted for Colomb's and Bolton's apparatus,; and the distinguishing signals, such as call signal, stop, &c., appended, explain their own meaning and use.

In concluding this description, I would beg to draw attention to the very great kindness exhibited by Colonel Baron Von Ebner, and all the officers attached to the Austrian military commission at the Paris Exhibition, who gave every facility to the officers of our own corps, as well as to myself, for inspecting all the articles shown by the Austrian War Department, and who spared no trouble in giving personal explanations of the same on many occasions.

R.H.S.

(A.)

LONDON INDIA RUBBER WORKS, MITCHAM.

Description of Mr. Hooper's Patent Insulated Wires and Cables exhibited in the Paris Exhibition.

No. of Specimen.	Conductor.			Hooper's Patent Dielectric.		Resistances per knot, temperature 75° Fah.		Gutta percha required for an equivalent induction, (inductive capacity), to Hooper's patent dielectric.	Outside diameter.	Total weight per knot.
	Consisting of	Weight per knot.	Diameter,	Weight per knot.	Diameter.	Conductor B.A. Units.	Dielectric Millions B.A. Units.	Diameter.		
		lbs.	inches.	lbs.	inches.			inches.	inches.	lbs.
383	7 No. 18's.	300	·147	300	·374	4·522	5,000	·472	·400	640
320	7 No. 20's.	180	·110	336	·380	7·052	7,949	·518	1 300	8420*
353	7 No. 22's.	109	·087	346	·380	12·007	9,200	·549	·400	501
370	7 No. 18's.	300	·147	248	·340	4·052	5,062	·419	·360	585
373	7 No. 20's.	180	·100	264	·340	7·052	6,000	·450	·360	481
375	7 No. 22's.	109	·087	274	·340	12·007	6,949	·478	·360	420
372	7 No. 20's.	180	·110	200	·300	7·052	5,000	·385	·320	407
322	7 No. 22's.	109	·087	210	·300	12·007	6,444	·409	·780	2436†
323 A	3 No. 21's.	62	·064	160	·260	23·047	8,000	·369	·280	244
321	No. 16	72	·063	133	·240	19·011	6,326	·335	·260	223
321 A	3 No. 20's.	78	·070	132	·240	17·061	7,884	·326	·260	228‡
376	3 No. 21's.	62	·064	136	·240	23·047	7,890	·331	·260	216§
358	No. 16	72	·063	90	·200	19·011	4,000	·296	·220	177 ‖
323	4 No. 22's.	62	·067	92	·200	23·047	4,000	·263	·220	169 ‖
351	No. 18	44	·049	42	·160	30·040	3,500	·215	·180	112
	Mr. L. Clark's segmental wire.	220	·110	336	·380	6·025	7,949	·518	1 300	8420¶

REMARKS.

*This Cable connects India and Ceylon. The shore end contains 12 No. 3½ iron wires, but in other respects is similar to the Persian Gulf Cable. Fifty miles of the same core and a similar length of cable have been supplied and shipped to India for the government for river crossings.

†This Cable was supplied to the government, for Australia.

‡The multiple Cable connecting Ireland and Scotland, contains this as the centre core.

§This Cable was supplied for the Abyssinian Field Telegraph.

‖These cores are extensively used in India, on the principal railway telegraphs, and in the government offices.

¶This Cable is laid off Reshire, in the warmest part of the Persian Gulf, and is officially reported to the government to be, after 4 years, three times better than the gutta percha of the Persian Gulf Cable.

These cores are supplied with an external covering of [illegible] tape. The diameters are given in thousandths of an inch.

The diameters of the strand conductors are those of the circle circumscribing the strand.

The resistance of a gutta percha core, compared with the resistance of Hooper's Core, can be calculated from any of the above resistances.

See Page 72.

(B.)

DESCRIPTION OF VARIOUS CABLES FOR MILITARY PURPOSES.

No. of Cable.	Price per Statute Mile, free on board, in London, including packing.	Total weight per Statute Mile.	DESCRIPTION.
	£ s. d.	Cwt.	
3006	85 0 0	6	1 conductor, consisting of a strand of 3 soft iron wires, each of 0·05 inch diameter, insulated with 2 layers of gutta-percha and compound to 0·236 inch, sewed with best Italian hemp strings, and covered with one continuous copper sheathing to a total diameter of 0·39 inch.
3029	81 0 0	4½	1 conductor—strand of 3 soft iron wires, each 0·03 inch, covered with 3 layers of vulcanized india-rubber to 0·264 inch, 1 layer of hemp, sheathed with copper sheet, and covered with tape painted white.
3030	81 0 0	4½	Same as last, but covered with plaited hemp instead of painted tape.
3031	70 0 0	4¼	Same as 3029, but no outer covering of tape or hemp on the copper.
5014	63 0 0	2½	Same conductor as 3029, sewed with hemp, and covered with tape painted white, with no copper sheathing.
5015	63 0 0	2½	Same as last, but covered with plaited hemp instead of painted tape.
5017	48 0 0	1¼	1 conductor—strand of iron wires, each 0·03 inch diameter; 1 layer of vulcanized india-rubber, 1 layer of tape, 1 layer of vulcanized india-rubber, and outer covering of tape.

See Page 73.

3, *Great George Street, Westminster*,
17*th July*, 1867.

PAPER VI.

DESCRIPTION OF AN APPLICATION OF PHOTOGRAPHY TO SURVEYING PURPOSES, CALLED "LA PLANCHETTE PHOTOGRAPHIQUE,"

In the Paris Exhibition of 1867.

By CAPTAIN R. H. STOTHERD, R.E.

The attention of photographers has recently been much turned to the utilization of this very useful branch of art, and many excellent applications have been discovered, the practical results of which may be seen every day. There is, for example, the very beautiful process of the reduction of plans by photography from a large to any given smaller scale, by which the saving of time and labour is enormous, and the accuracy obtained far greater than that which would result from any mechanical mode of reduction. Again, there is the photo-lithographic process, and others besides which it is unnecessary here to enumerate. Among the most recent applications of photography is the attempt to bring it to bear practically on field surveying, and by it to obtain data from which an actual survey may be plotted as from an ordinary field-book. This has been done in Austria with considerable success; and again in the Paris Exhibition of 1867, Mons. Auguste Chevallier, No. 1, Rue de Condé, Paris, exhibited a very neat and clever instrument, designed with the same object in view.

The rapidity and accuracy with which photography, as applied in this way, is capable of recording, in true relative position, the different objects composing any view falling within the focus of the lens of an instrument, render it highly probable that at no very distant day it may come into general use for military purposes, and that instruments—if not like that of Mons. Chevallier, on somewhat similar principles—may form a part of the equipment of every army which takes the field; a description of it may, therefore, be interesting.

It consists of a stationary horizontal plate or table, supported on a tripod stand, over which a moveable plate is arranged to revolve, with an uniform motion, by the action of clock-work. This upper moveable plate is provided with a prism or mirror placed at (*a*) Fig. 1, by which the image of an object in front of it is projected upon the stationary horizontal plate (*b c*). By means of a simple arrangement fixed at the lower part of the tube (*f g*), carrying the

prism (*a*), the light can be effectually excluded at any point, during the period of its rotation. As the upper plate revolves, the image of each object, as it passes in front of the prism, is projected on the lower or horizontal plate in true relative position; and if a sensitized glass be introduced in connection with this stationary horizontal plate, a panoramic view of all objects presented during a single revolution of the upper one, is photographed thereon, each object being in truly mathematical relative position with all others in the same panoramic view, with reference to the central point on which the instrument revolves.

This central point, at which the instrument is placed, corresponds exactly with a trigonometrical station, at which, in the ordinary operation of surveying, a round of angles is taken by a theodolite, and the panoramic view corresponds to a round of observations, which are, however, in Mons. Chevallier's arrangement, recorded in the form of a picture, round the circumference of a circle, described with the trigonometrical station as its centre, whereas, in the ordinary mode of procedure, they are represented by a series of bearings, with reference to a given meridian, and recorded in the form of angles therefrom.

The opening in the upper plate, through which the image is projected upon the sensitized glass, is in the form of a slit, about one third of an inch wide in the outer circumference, and gradually tapering towards the inner circle, bounding the exposed surface, its sides being in the direction of the radii drawn from the centre of revolution of the instrument; in Fig. 1, the outer end of the slit would be at the point (*h*), and it would gradually narrow to the point (*g*), and the space between it and the centre (*k*), the pivot on which the instrument revolves, being completely covered by the upper plate, would, in the picture produced, be represented by a circle, on which no image would be photographed. A simple arrangement covers this slit and excludes the image till the moment for exposure arrives, when it is opened by turning a mill-headed screw. The time of exposure is regulated by the rate of the clock-work, each object being presented in succession on the sensitized glass, during the interval of time taken by the slit or opening to pass over the arc of the circle corresponding to it. The image can be cut off at any point required, during the revolution of the instrument, by simply turning the mill-headed screw already mentioned, so as to cover the opening, and thus any portion of the panorama may be photographed at will, without completing the whole revolution. The means of focussing is attached to the upright portion (*f g*), and a small telescope, in connection therewith, gives the power of regulating it, so that a sharply defined image may be obtained. The image produced in the glass is a negative, which may itself be used in plotting the different points of the panorama on the plan, precisely in the same way that a round of angles is plotted by means of a circular protractor; when there is time, however, a print from this negative affords a more convenient medium for this purpose. In making a survey with this instrument, a base, as (*a b*), Fig. 2, is measured, and panoramic views from its extremities, and from other points required, as for example at (*c*), are taken; and the positions of the most defined objects being laid down by plotting on the plan, by means of the pictures obtained, the remaining detail is readily inserted

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by minor measurements, productions, and intersections. Fig. 3 gives an idea of the form and general appearance of the instrument. Mons. Jonart, Lieutenant of Artillery of the Imperial Guard, has published a very interesting and detailed account of this apparatus and of its use, from his own practical experience, as a surveying instrument, combining as it does considerable accuracy with rapidity in obtaining the necessary data for plotting. The record being self-acting, no error can arise from a mistaken entry of a bearing. If a series of views were taken from prominent points, a system of triangulation might be rapidly carried over any district of country, and on this triangulation the detail could be very readily built.

It would be very desirable to test this instrument practically, in order to obtain some idea of its working powers. As regards its disadvantages, which appear to be the necessity of carrying about a dark tent and certain photographic apparatus, and the employment of trained photographers, I would observe that, as a photographic equipment will probably form an appendage of every army that takes the field in modern warfare, the first objection is scarcely worth considering, provided the instrument itself can be made in a sufficiently portable form for transport. As regards the necessity for providing skilled photographers to work it, men with comparatively little previous knowledge will answer the purpose, if first-rate hands cannot be obtained, because the pictures to be produced are not required to be kept as works of art, but are simply to be used for plotting purposes, for which such great perfection is not necessary. Mons. Jonart states that some of the negatives used by him in his surveys were taken by men who had had only three or four days' practice in photography.

In addition to the mode of working this instrument, already described, it may be used without clock-work, by simply arranging it to remain stationary at certain given points round the circumference of the circle of the panoramic view to be taken; the distance between the stationary points, at which the apparatus is fixed for each view, being regulated by the space on the sensitized glass on which the image, of the view to be taken, will be cast in proper focus. The effect of this process is to produce a series of views, forming a panorama, and, in point of fact, giving a very similar result for working purposes to that obtained with the clock-work. The only difference being that in the one case a series of views is produced, whereas, in the other, the result is one continuous picture, extending without a break completely round the circle.

When no clock-work is used, the arrangements for exposing the sensitized glass are somewhat different from those required with the continuous action as already described, a broader space being exposed for a certain definite interval of time, and then the apparatus passed on to the next space, which is in its turn exposed, and so on till a complete circle, or portion of a circle, has been photographed. The instrument exhibited in Paris at the International Exhibition, excited a great deal of interest. It is a comparatively new idea, and it is to be hoped that it will prove as useful as its inventor anticipates.

R. H. S.

PAPER VII.

REVOLVING MUSKET PROOF MANTLETS FOR EMBRAZURES, &c.

By QUARTERMASTER J. JONES, R.E.

The mantlets to be made of homogeneous iron, weighing about 6 lbs. per superficial foot, or of such thickness as will resist rifle bullets.

The mantlets to consist of one plate about 8 feet long, and of sufficient width to overlap the sides of the embrazures two inches on each side. Each plate to have a hole in the centre, of the same diameter as the centre pin on which it revolves. The mantlets to be secured on the centre pin by a nut or pin.

The centre pin to be wrought iron $2\frac{1}{4}$ inches diameter, fixed into the parapet one foot below the sill of the embrazure.

In casemated batteries two iron cramps, could, if necessary be inserted into the parapet to support the mantlets at the upper edge. (See plate.)

The mantlets to be raised and lowered by hand, and kept in position by two moveable stops, driven into the parapet.

For open batteries in the field, an iron bar could be driven into the interior slope, and at right angles with it; the bar so driven to act as a centre pin for the mantlet to revolve on.

Mantlets on this plan possess the following advantages:

1st. Simplicity of construction and working.

2nd. Being reversible, each embrazure would be supplied with two mantlets instead of one.

3rd. Could be made to resist any sized shot.

4th. Easily removed when damaged.

The following extract from the report of the Ordnance Select Committee on this mantlet, is published by permission.

Quartermaster Jones, R.E.—Revolving Musket-proof Mantlet for Embrazures.—Minute 21652, 8. 4, 67.—Report No. 4551.—(10th April, 1867.)

"The mantlet proposed by Quartermaster Jones is to be made of homogeneous iron, of such thickness as will resist penetration by rifle bullets. Each mantlet is to be 8 feet long, and of sufficient width to overlap the sides of the embrazure by 2 inches on each side. It is proposed that the mantlet should be arranged to revolve on a centre pin fixed into the masonry, 1 foot below the sill of the embrazure, and it requires in the model that a slot be cut in the floor to let it revolve."

"The construction and mode of action are extremely simple. The weight from 3 to 4 cwt. (according to width), would probably not be inconvenient as it is counterpoised, and where the weight of the sill of the embrazure is such that the floor need not be cut, or the construction of the work allows of that operation, it would probably be found quite as suitable as the mantlets of Captain Du Cane and Mr. Millard's patterns, (Report No. 3,201, Minute 11,131), which have already been favourably reported upon; perhaps more so. As, however, the nature of mantlet best applicable to a particular work must necessarily depend upon local circumstances, the Committee can only suggest that Quartermaster Jones's mantlet be recognised as one of the ways by which embrazures, in iron or masonry, may be protected from the effect of musketry fire."

J. J.

PAPER VIII.

REMARKS ON GABIONS.

By QUARTERMASTER J. JONES, R.E.

In the last volume of the Corps Papers, the remarks of Captain Percy Smith, R.E., advocating the superior merits of the wire gabion, as compared with the wicker, sheet iron, and iron-band gabion, seem to me to lead to conclusions not strictly correct.

Captain Smith states :—

1st. "That the iron-band gabion does not possess the capabilities of being strengthened."

2nd. "That it does not possess the capabilities of being repaired."

3rd. "That it splinters."

4th. "That it partly possesses simplicity, lightness, noiselessness, and cheapness."

As to the first point, "that the iron band gabion does not possess capabilities of being strengthened," I consider that under no ordinary circumstances does it require strengthening, but should this ever be necessary, the bands can easily be used in two thicknesses and additional pickets added.

The second point urged is "that it does not possess the capabilites of being repaired." One of the chief characteristics of the iron band gabion, is, that it is easily repaired when damaged.—Corps Papers, Vol. VIII., Paper XI.

The third point is "that it splinters."

When the iron band gabions were tested as a revetment for embrazures, by Colonel Shakespear, R.A., Captain G. H. Gordon, and Lieutenant Vetch, R.E., at Romney Warren, on the 24th August, 1861, against the wicker and sheet iron gabions :—

Colonel Shakespear in his report said "The result of this practice shows that these gabions do not splinter, nor could any harm happen to men employed in working the guns in these embrazures, from pieces of the metal falling off from the gabions."

"I noticed large strips come off, but they fell close at hand without any appearance of flying in the shape of splinters."

"The gabions were knocked to pieces when struck, but those in the centre appeared by far the most useful, they held the sand better, and did not break so much as those of Captain Tyler, the bands merely stripping when struck."

Captain Gordon, R.E., in his report said "There were, however, no splinters of any consequence."

"Jones's gabions appeared to have an advantage in not tearing so much as Tyler's."

"The wicker gabions appeared more liable to splinter than the others, as several more pieces of them were found inside the parapet, than either of the iron gabions."

The following is an extract from Lieutenant Vetch's report :—

"The fragments of shell hit three of Jones's gabions on the left cheek of the embrazure ; there were no splinters, but small holes were made in the bands."

"Three gabions 'Jones's' in the right of embrazure much cut, but no splinters."

At the experiments made at Shoeburyness on the 8th and 11th April, 1864, with 12-pounder field guns, against a three gun battery, the right embrazure revetted with the sheet iron, and the centre and left with the iron band gabions, it was found that after firing 90 rounds of shell, and 45 of shot *into the embrazures*, there were only *five splinters* in the interior of the battery.

In rear of this battery there were three gun detachments, represented by 30 wooden gunners, of this number 30 were struck once, and 7 twice by shot and shell, but not one was even touched by a gabion splinter.*

The fourth conclusion urged is, that the iron band gabion only partly possesses simplicity, lightness, noiselessness, and cheapness.

"Simplicity."—Colonel Lennox, V.C., C.B., has omitted the making of the iron band gabion from the course of field word instruction, at the Royal Engineer Establishment, Chatham, on account of its *simplicity*.

* The following Corps General Order, No. 478, issued a short time after the experiments above referred to, is very clear as regards the subject of danger from splinters : "At some recent experiments with 12-pounder field guns against embrazures lined with metal gabions of Captain Tyler's and Quarter Master Jones' patterns, His Royal Highness the Field Marshal Commanding-in-Chief observed that particles of iron from each were scattered with such force into the interior of the battery as to manifest clearly that gabions of those patterns are inappropriate for that particular application. His Royal Highness therefore desires that the use of these descriptions of gabions for revetting embrazures, traverses, and other places exposed to direct fire, be discontinued."—Editor.

"Lightness."—If much lighter, it would have one of the same defects as the wire gabion, viz., want of stability.

"Noiselessness."—It has been proved by practical experiments that they can be used without noise.—Vol. VIII, Paper XI., Corps Papers.

"Cheapness."—If the bands were made for gabions only, they would be cheaper than the wire gabion. Captain Smith omitted (unintentionally) to state that the present gabion bands are prepared on the recommendation of the Ordnance Select Committee and Royal Engineer Committee, for bridging purposes also.

It is an indispensable requisite in an iron gabion that it should possess stability.

I shall conclude by remarking that when the wire gabions of Captain Smith and Mr. Newton were tried at the Royal Engineer Establishment, Chatham, in 1863, an attempt was made to construct a flying sap, with the following result; viz., all the gabions were knocked over *two* or *three* times; this was done in the day-time; filling them at night would be a hopeless undertaking in the face of an enemy, unless an extra sapper be detailed to hold each gabion. Moreover, want of stability was not their only defect. It was found that when the gabions had received the usual slope, the height at the back had diminished from 2 ft. 9 ins. to 2 ft. or less. If another tier had been placed *(which has not yet been attempted)*, the lower ones would be crushed by the superincumbent weight, to about 1 foot in height.

The wire and iron band gabions have been referred to the International Exhibition Committee, 1862, and to the Royal Engineer Committee; neither of the Committees has been able to arrive at the same conclusion as Captain Smith.

The former Committee awarded a medal to the iron band gabion, and the latter Committee reported that the iron band gabion was the best for all field purposes.

J. J.

Chatham, 26th September, 1868.

PAPER IX.

REPRESENTATION OF GROUND.

BY LIEUT.-COL. H. Y. D. SCOTT, R.E.

I think the Corps must be weary of the question of the representation of ground, side light, shading by inclination, and pictorial scales, but as it appears right that the "scale of shade" adopted by the Council of Military Education should be made known to our officers through the Professional Papers, which contain the whole discussion, so far, I venture to propose this short article for admission to them. I am the more ready to do this, because, although the Corps is now pretty unanimous on the advisability of adopting some uniform plan for military sketching, it has not yet been so generally conceded that in field sketching for national surveys or surveys of extensive tracts of country, the *field* draftsmen should be trained to shade by inclination only, leaving it to the *indoor* draftsmen to supply, in the finished maps and plans, such pictorial effect as may be considered necessary.

The more attention is directed to the subject the greater the probability, I think, that the unavoidable inaccuracies of the best hill sketchers will become apparent, and when once the difficulties of the process are fully felt, all will be desirous to limit his task as far as possible. However simple the scale of shade may be, the most experienced draftsman will make but imperfect use of it, and those who have to interpret his work will find it sufficiently exercise their attention and patience. A mere variation in the tint of the ink employed may mislead either him or them; and if he be told that the thickness of the strokes required by the inclination of the ground is to be modified as he ascends above the sea level, and that then modifications are further to be varied according to the amount of light due to the direction of the ever varying slopes with respect to its supposed source, we may rest assured that the first bewilderment over, and the full difficulty of the task given him realized, no sort of accuracy, even as respects inclination, will be attempted, and altitude and side light will be only so far regarded as they will help him to make a pretty picture.

On the subject of military sketching, however, there is no longer any difference of opinion as respects questions of altitude and side lights. It has been conceded that shading by inclination only is sufficient for the purpose, and the points now in dispute are comparatively of trifling importance. The necessity of uniformity of system is generally felt, and the horizontal hachure has been adopted finally at our military colleges. The discussion is, in fact, narrowed to details; to considerations of the thickness of stroke which it is advisable to

employ; at what distances apart the strokes should be drawn; and what proportion of light and shade should be allotted to different inclinations. Whether, again, the contours on which the work is based should be preserved, and, if preserved, whether they should be indicated in red lines, in blue lines, or in dots. On most of these points much has been said and written, more, perhaps, than the case justified; and I now propose to increase the quantity only by so much as will enable me to recapitulate my own views, stated in Vol. XII of our Corps papers, and now acted on by the Council of Military Education after a patient consideration of all the opinions advanced. These views may be thus summed up.

Close approximations to the relative altitudes of the features of ground can only be obtained by means of numbered contours, or by altitudes marked on the plan.

The pictorial effect which is to convey to the eye at a glance the general conformation of the ground and the character of its slopes, must be obtained by shading.

The system adopted should allow of the representation of the manœuvring slopes as perfectly as possible.

It must also be such as can be readily employed by an ordinary draftsman, and must, therefore, be simple in principle and free from artistic difficulties of execution.

The simplest principle is to give to the same vertical interval, whatever the inclination of the ground to be represented, the same absolute amount of shade, without reference to side light or altitude above the sea level.

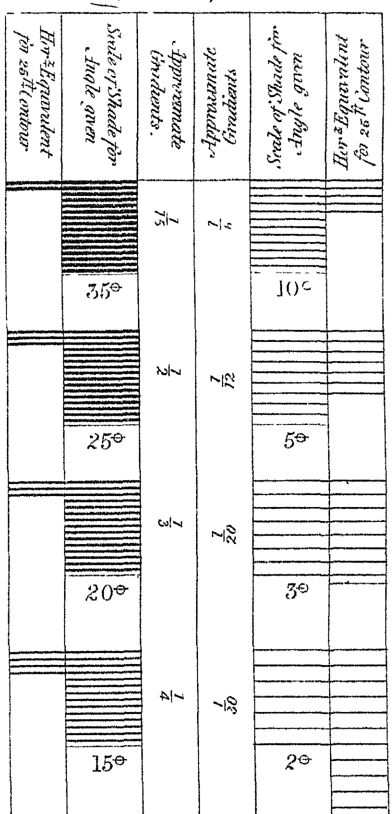
The easiest mode of shading with the pen and pencil is to assign such thickness and proximity in the strokes employed as will produce a pleasing effect to the eye without taxing the draftsman's manipulative skill, or causing unnecessary waste of time.

The result of training draftsmen to work to one scale of shade will be greater uniformity than we obtain by allowing each man to work according to his own fancy at the moment.

These propositions really embrace all that I have advocated as essential, and the scale first proposed by me was based on the best sketches I could obtain. I subsequently modified this scale by spacing the strokes rather wider apart, to render the work of easier execution by moderate and inexperienced draftsmen. The accompanying scale, which I finally submitted to the council, after I had had the advantage of having the opinion of others on the subject, and which the council has adopted, proceeds a step further in the same direction. The strokes are as far apart as they well can be without producing a rawness of effect. Some may consider that too much has been sacrificed to ease of execution, but I think that for the scale of 6 inches to a mile, there are few cases in which the greater facility and rapidity of execution which it allows do not more than compensate for the loss of some softness in drawing.

H. Y. D. S.

Shades for Scale of 6in to a mile



From 35° to 45° the lines may increase in thickness according to the draughtsmans skill, their number being constant

PAPER X.

DIAGRAM ILLUSTRATING THE COURSE OF PROMOTION IN THE CORPS OF ROYAL ENGINEERS.

By LIEUTENANT G. E. GROVER, R.E.

1. The accompanying diagram has been compiled from the yearly Army Lists published since 1757, when the Engineers first received military rank.

2. During the 40 preceding years, the Engineer establishment—as constituted by an Order in Council, dated the 22nd August, 1717—stood as follows:

			£	s.	d.	
1	Chief Engineer	at	1	7	6	per diem.
2	Directors	each	1	0	0	„
2	Sub-Directors	„	0	15	0	„
6	Engineers in ordinary ..	„	0	10	0	„
6	Engineers extraordinary ..	„	0	6	0	„
6	Sub-Engineers	„	0	4	0	„
6	Practitioner Engineers ..	„	0	3	0	„
Total..29						

and the commissions were signed by the Master General of the Ordnance.

3. On the 14th May, 1757, King George III. signed commissions for—

1	Chief Engineer	as Colonel.
2	Directors	„ Lieutenant Colonel.
3	Sub-Directors	„ Major.
8	Engineers in ordinary ..	„ Captain.
8	Engineers extraordinary ..	„ Captain-lieutenant.
12	Sub-Engineers	„ Lieutenant.
16	Practitioner Engineers ..	„ Ensign.
Total... 50		

with the same rates of pay as detailed in the foregoing paragraph, except that the Sub-Engineers and Practitioner Engineers received, each *per diem*, 4s. 8d. and 3s. 8d. respectively.

4. An Order in Council, dated the 3rd March, 1759, augmented the above establishment by 1 Sub-Director, 4 Engineers in ordinary, 4 Engineers extraordinary, and 2 Sub-Engineers.

5. The Army Lists for 1758 and 1759 designate the Engineer officers as described above in paragraph 3 ; but that for 1760 shows an actual, instead of a relative, military rank for all grades, except that of the "Chief Engineer," who is still entered "*as* Colonel," whilst the following titles are "Director *and* Lieutenant Colonel," "Sub-Director *and* Major," "Engineer in ordinary *and* Captain," and so on. The Army List for 1771 is the first to show a "Chief *and* Colonel;" but the rank of Chief Engineer fell into disuse, on the re-establishment of Colonels Commandant in 1802-3. Sir William Green, the last Chief Engineer in the Corps of Royal Engineers, died* early in 1811, having attained the rank of General in the army on the 1st January, 1798.

6. In 1776-7, the "Practitioner Engineer" was commissioned a Second Lieutenant—instead of an Ensign, as before. The rank of Lieutenant lapsed for 71 years, viz., from 1785 to 1856; and that of Captain-lieutenant was transformed into Second Captain in 1804-5.

7. In 1782 the Engineers' grades were first denoted by simple military rank, in place of the special professional titles they had previously borne. At the commencement of that year, the establishment was as follows:—

1 Chief Engineer and Colonel.
2 Directors of Engineers and Lieutenant Colonels.
4 Sub-Directors of Engineers and Majors.
12 Engineers in Ordinary and Captains.

* The curious inscription on his monument, in the Plumstead Old Churchyard, has much puzzled epitaph-collectors ; and, as it will soon be illegible (from the decay of the stone), the following copy of it may possibly prove interesting :—

S. S. S.
Interred lie the mortal remains
OF GENERAL SIR WILLIAM GREEN BART.
Chief Royal Engineer
Departed this life 11th Jan'y 1811
Aged 86 years.

Efficient duty reminiscent grave
Yet mild philanthrophy a reign may save
If but the mind incline, rare to deny
Courteous humane to misery a sigh,
To woe and wretchedness a constant friend.
What's this proud course ? a rind, an atom, cloud
Soft sweep the lyre, pity her distress,
Compassion's melting mood his numbers bless ;
On these perhaps our future joys depend.

Aided by the interference of an honorable friend
In the Royal Corps of Artillery
We have further consigned to memory
A tablet in the sanctuary of the church.

I. W. G.

12 Engineers Extraordinary and Captains Lieutenant.
14 Sub-Engineers and Lieutenants.
30 Practitioner Engineers and Second Lieutenants.

Total .. 75

and the changes of rank brought about in succeeding years will be understood from the following table:—

ENGINEER ESTABLISHMENT.	1783 and 1784.	1785.	1786.
Chief Engineer	1	1	1
Colonels Commandant...	6	6	—
Colonels..........................	—	—	6
Lieutenant Colonels	6	5	5
Captains	9	22	22
Captains-lieutenant and Captains	9	—	—
Lieutenants	21	4	—
First Lieutenants.................	—	17	21
Second Lieutenants...............	22	17	15
Total	74	72	70

8. The Army List for 1757 contains a "List of Engineers in Great Britain." That for 1758 shows "Engineers, Rank as Officers of Foot." That for 1773 first shows "The Corps of Engineers;" and, not until the year 1788 does the official Army List make mention of "The Corps of Royal Engineers."

9. The Army List for 1758 is the first in which the dates of the Engineers' commissions are inserted. That for 1757 particularises the names of Officers in, and the daily rates of pay received by, each rank of the Engineers; but it omits to state the dates of their respective commissions.

10. Hence the omission, from the accompanying diagram, of some of the very earliest ranks of Officers in the Corps. The dearth of official records, in this respect, might doubtless be compensated for by a gleaning from private sources, but at the expense of more labour than the present subject would really seem to warrant or require.

G. E. G.

Royal Arsenal, Woolwich,
18th November, 1868.

PAPER XI.

ABYSSINIAN EXPEDITION.

REPORT FROM LIEUT.-COLONEL ST. CLAIR WILKINS, R.E.

Commanding Engineer, A. E. F.

To Captain T. S. Holland, Assistant Quarter Master General, A. E. F.

Head-quarters, Zoolla, 30th May, 1868.

Sir,—I have the honour to submit for the information of His Excellency Lieutenant General Sir Robert Napier, G.C.B., and G.C.S.I., Commander-in-Chief of the Abyssinian expeditionary force, a brief report of the operations of the Engineer department in Abyssinia; of the services of the officers of the departments; together with a report, in detail, of the several works executed.

2. Plans of the port, coast, depot, and camp of Zoolla, the railway line, and other works, are annexed. (See Pls. I, II, and III.)

3. The officers of the reconnoitring party despatched from Bombay on the 16th of September last year, having, on the 2nd of October, examined the port of Massowah and the water supply of that port on the plains of Mucculllo, five miles distant from the sea, formed the opinion that that harbour was too small to accommodate more than half-a-dozen vessels, and that the water supply was of too limited and precarious a nature to meet the requirements of the expedition. The *Euphrates* and the *Coromandel*, containing the exploring force, steamed southwards into Annesley Bay, and the water supply at Negoosa, on the promontory of Buri, was examined without satisfactory results. Crossing the bay, the vessels took up a position off the village of Zoolla, and the water supply from the Haddass river promising fairly, and an investigation of the shores round the bay, combined with information obtained, presenting no better prospect, it was determined to make Zoolla the base of exploration in the country.

The beach at Zoolla shelving very gradually into the sea, it became at once a matter of great importance to commence the construction of a suitable pier for landing purposes. Some iron girders and stout rafters had been brought up in the steamers to assist in forming a pier, but from the nature and formation of the shore it was apparent that a long pier would have to be constructed from local resources. The plain bounding the sea was covered with low bushes, but unfortunately no stone was to be had. Under these circumstances, fascines were

prepared from the brushwood, and being strongly staked down, formed retaining fences for the filling in. Arrangements were at once made for the collection of native crafts from Massowah and neighbouring ports, and the conveyance of stone from the opposite side of the bay commenced towards the middle of October. Sea walls were then built outside the fascines, and by degrees the pier was run out 900 feet into the sea, giving a depth of 5 feet at low water springs. The greater portion of the pier was filled with stone.

This stone pier was completed sufficiently to be used in landing the advanced brigade and their horses, in November, and by the middle of December the pier was in general use, having a tramway laid from its head to some distance up the beach, thus greatly facilitating the landing of commissariat, land transport train, ordnance, and other stores. A tramway was laid down on the beach, running down to low water line, early in October, and was of much service previous to the pier coming into use. In this month also, a road 50 feet in breadth was cleared through the jungle from the pier to the camp, 1¼ miles distant. By the end of November, the works executed at Zoolla, comprised the nearly finished stone pier; a cleared road to camp from the sea; the clearing out of the old village wells in the bed of the Haddass river; and the construction of twenty new ones, whereby about 2,000 men and 2,000 animals, were watered daily; a large store shed and a water shoot, 480 feet in length, raised on trestles above the sea, for conveying to the tanks (which were being collected on shore) sweet water, condensed by H.M.S. *Satellite*. The satisfactory progress made with the Zoolla works generally, up to the close of the year, is attributable to the untiring zeal and energy displayed by the officers in executive charge.

Captain N. W. Goodfellow, R.E.

Captain N. W. Goodfellow, Field Engineer, and 2nd in command of Royal Engineers with the Force. It is unnecessary for me to bring this officer's subsequent services to his Excellency's notice, those services having been performed under his Excellency's own observation. I would wish, however, to record how highly I appreciate Captain N. W. Goodfellow's services, and how much I feel indebted to him for his support and example, and for the cheerfulness and fertility of resource he has so constantly displayed.

On his Excellency's arrival at Zoolla early in January, many additional commissariat and other sheds had been erected, and the commencement made of a second pier, a pile pier, the materials for which had been prepared and sent out from Bombay.

Capt. Chrystie, R.E. (Madras)

Captain Chrystie, R.E., Field Engineer, assumed charge of the Zoolla works on the 1st of January, and in his hands the pile pier made rapid progress and was nearly completed up to the island by the 5th of February, when Captain Chrystie, was ordered to Senafe, and was relieved at Zoolla by Captain Wood, R.E., Field Engineer.

Captain Wood, R.E. (Madras).

Captain Wood completed the pile pier, and built a new head to the stone pier, greatly improving it. Captain Wood's work was distinguished by its solidity and permanent character. That the piers were not damaged by the late gales is attributable to this officer's good

work at the head of the piers. Captain Wood was unfortunately taken ill, and had to go on board the hospital ship, Lieutenant Lee, R.E., Assistant Field Engineer, assuming charge of the Zoolla works. I have much pleasure in testifying to the excellent character of the works carried out by this officer, who has had many years' experience on public works. Lieutenant Lee completed the works at Zoolla as they now stand.

Lieut. Lee, R.E.

A tramway having been proposed to be laid in the lowland country between Zoolla and the base of the mountains, at Koomaylee, a distance of about twelve miles, Lieut. Willans, R.E., Assistant Field Engineer, commenced surveying the line in November, and the works were commenced in December, when the ships with the plant from Bombay began to arrive.

Lieut. Willans, R.E.

An iron girder bridge of three spans of 20 feet was constructed over a branch of the Haddass river in December, and about a mile of earthworks was constructed, and rails laid by the end of January.

Six miles of railway, with a branch of half-a-mile to the commissariat sheds, were completed by the 19th February, and the Commissariat Department commenced running all their stores and provisions to the 6th mile siding. This enabled the Land Transport Train to move the whole of their animals from Zoolla, thus relieving the water-condensing operations enormously, and saving considerably in time and animals in the trip from the coast to Senafe.

All commissariat and other stores now sent out to the 6th mile siding were conveyed away by carts and baggage animals, sent out from Koomaylee, and which returned to that post the same day. A second commissariat siding was opened for traffic at the 9th mile from Zoolla on the 28th March, thus further reducing the labour of the transport animals.

At the end of April, the railway was completed to within a mile of the camp at Koomaylee. The traffic on the line had now become so great, that the commissariat department absorbed the whole of the rolling stock. It was found that what with the commissariat requirements, and the increased time taken up by the lengthened journey, trains for the conveyance of railway plant could no longer be given. With extreme reluctance it was then decided that the works must be brought to a close, by the construction of a loop line and terminus, at about a mile from Koomaylee. The heat in the plains was so great when the works were being closed, that not more than $5\frac{1}{2}$ to 6 hours work could be obtained from the workpeople.

By great good fortune water was obtained from wells at the fourth, seventh, and ninth miles in the line, by the excavation of wells, 50, 65, and 85 feet in depth respectively, at each point named. Watering tanks for the engines were set up by the side of the line, and fed from these wells by piping. A good supply of water being obtainable at the fourth mile, "Pioneer Wells," the locomotive workshops were established at this place. It was also found desirable that the whole of the locomotive establishment should be permanently situated at the Pioneer Wells, so as to be close to their work.

The railway, properly speaking, is only a tramroad, so far as the rails and

rolling stock are concerned. The rails are light, and the rolling stock consists of contractor's engines and trucks, nevertheless, the tramroad has been called upon to do the duty of a railway, and it has, by constant care and management, been kept up to the work required of it. The main line from Zoolla to Koomaylee is 10½ miles in length, and altogether 12 miles 106 yards of rails have been laid. For the first 6 miles the plain rises pretty gradually from the sea, to a height of about 100 feet above that level. The railway line then passes through a low range of hills, keeping the bank of the river; there is some heavy work on this portion of the line, in cuttings, embankments and bridges. The line then descends about 50 feet into the Koomaylee plain, and rises to a height of 348 feet, at the Koomaylee terminus. Eight iron girder bridges and a large number of drains have been constructed on the line.

The whole of the railway, earthworks, embankments, cutting bridges, and drains, have been executed by troops of the force and by men of the Army Works Corps. A few civilian platelayers, some from Bombay, and some obtained from the shipping and departments of the army, have superintended the platelaying. The greater portion of the railway has been constructed by the 23rd Punjab Pioneers, commanded by Major Chamberlain, and the 2nd Bombay Grenadiers, under Lieut. Colonel Muter. I am particularly desirous that the services of these two corps, in performing a duty so utterly new to them, should be brought to His Excellency's notice. The cheerfulness and willingness on the works of the men of these corps, inspired by the spirit and tone of their officers, have been most conspicuous and are deserving of the highest praise. The Punjab Pioneers are very clever and quite artistic in all they do, under the guidance of their skilful commander. The wells made by them at the station called "Pioneer Wells" and at the bridge are models of skill in well digging. The 2nd Grenadiers worked on the line during the hot season, but they always evinced the greatest alacrity and desire to further the work.

Captain Darrah, R.E., and assistants.

I respectfully wish to bring to His Excellency's special notice the services of Captain Darrah, R.E., Field Engineer, who has superintended the railway works from the commencement to the completion; as well as the services of his assistants:—Lieut. Willans, R.E., A.F. Engineer; Lieut. Pennefather, R.E., A.F. Engineer; Lieut. Baird, R.E., A.F. Engineer; Lieut. Graham, 108th Regiment, A.F. Engineer.

Lieut. Willans, R.E., commenced the railway survey on the 16th November, and he remained on the works, superintending the bridges, till 15th March, when he was ordered to the front. He returned to Zoolla on 20th May, and resumed his position on the railway.

Lieut. Pennefather joined the railway works on 23rd December, and he has never left the works for a day up to this time.

Lieut. Baird, R.E., arrived from Bombay on the 28th February, and he at once took up the appointment of traffic manager of the line.

Lieut. Graham, 108th Regiment, joined Captain Darrah on the 20th January, and he has been on the works the whole campaign.

As the railway works have been carried out under my own supervision, I am

able to speak from personal observation of the devotion to duty displayed by Captain Darrah and his assistants. Early and late, day by day, for upwards of five months, have these officers, under most trying circumstances of climate, strained to the utmost of ability and strength to further the success of the expedition, so far as the railway was concerned.

His Excellency should be informed of the exemplary conduct throughout, of the undermentioned non-commissioned officers, employed on the railway works from nearly the commencement to the completion. All skilled men, the value of their services has been increased by their good conduct. Corporal Heinig, R.E., 10th Company; Sergeant Webb, Corporal Ricks, Private Cooper, Private Cox, 1st Batt. 4th (King's Own) Regiment; Private Miller, 45th Foot.

The difficulties of constructing a railway with unprofessional labour have been greatly enhanced, from the circumstances of five different descriptions of rails having been provided for the work, on four different principles of fixing. Had it been possible to land and carefully stack each description of rail prior to platelaying, the variation in the rails would not have been the cause of much inconvenience. As it happened this difference of pattern proved the most annoying, for the disembarkation of the plant just kept pace with the requirements of the works, and the line was fed from hand to mouth throughout. Consequently there was no time for sorting and stacking. The Kurrachee rail has given the greatest trouble in laying and maintenance, being very much worn and bent, and being a joint-chair and not a fish-plated rail. The 40lb. fish-plated rail would have been more useful, if the fish plate holes had fitted those in the rails. In five cases out of ten they did not fit, nor would the bolts go through the holes.

My opinion is that railways required for the operations of war should be carried out entirely as a civil work by engineers and contractors who make it their business to construct railways, and who would bring to bear on the works their own experience and that of professional establishments. In the present case it is worthy of remark, as a set off, that although the railway works have not been constructed so well or so quickly as they would have been by a professional contractor, yet the line was made in time to be exceedingly useful, and the difference of expense between the two systems is very great.

I understand the tender of an eminent contractor for making the Abyssinian railway was at the rate of £6,000 a mile, which would have brought up the cost of the whole line to about £72,000, exclusive of rails and plant. As near as I can ascertain, the cost of making the Abyssinian railway has been about £6,000, exclusive of rails and plant.

It must not be supposed from this statement, that the contractor (had the line been let to him) would have made a large profit. His expenses would have been very great for labour and superintendence.

Roads. Early in November last year, when it was determined to explore the Koomaylee pass, No. 1 company of Bombay Sappers was set to work in the Sooroo defile, under the superintendence of Lieut. Jopp, R.E., Assistant Field Engineer.

From the time of the Koomaylee pass being adopted as a route, strenuous exertions were made to construct a cart road through the Sooroo defile. The road was completed by the 31st January, the works having been well carried out under the directions of Lieuts. A. K. Jopp, R.E., Lieut. (now) Captain Sturt, R.E., and Lieut. Coaker, R.E., who are deserving of his Excellency's notice.

The Sooroo defile occupied the labour of two companies of Sappers and two companies of Belochees for three months. The road when completed had a breadth of about ten feet, and was constructed on the principle of ramping over boulders and obstacles instead of attempting their removal by blasting. The boulders which it was necessary to remove with the miner's drill were found to be of the toughest description of granite, and for some time the Sappers were unable to make any impression upon them. Almost simultaneously with the construction of the Sooroo defile road, the work of clearing a cart road the whole way from Zoolla to Senafe, a distance of 63 miles, was taken in hand. The rise in this road, in the length of 63 miles, is 7,400 feet.

About a mile of defile road at Rayrayguddy had to be built much in the same manner as the Sooroo, and at $1\frac{1}{2}$ miles from Senafe, a ghaut road, $1\frac{1}{2}$ miles in length had to be cut out of the mountain side. The whole road was open for cart traffic in the early days of February. The road had been kept in a perfect state of repair up to the 8th of May, when thunder storms commenced breaking over the passes, and doing serious damage to the road.

A cart road was also made between Senafe and Addigerat, a further distance of 37 miles. Two pieces of ghaut road occur on this line, the Goon Goona and Kersubba ghauts from Addigerat to Antolo; so much of the route was cleared as to render it passable for the G 14 battery to be driven to that post.

Beyond Antolo to Magdala, the road can only be described as a track passable for laden mules and elephants. An alternative route was commenced by the Haddass river, but was abandoned through sickness of the troops engaged and from other causes.

Capt Hills, R.E.

Captain Hills, R E., Field Engineer, who had the post of Executive Engineer at Koomaylee and Senafe during the campaign, has exerted himself in a very creditable manner, in exploring for the best line of road to be taken along the Haddass.

Water Supply.

When large bodies of troops and followers had landed at Zoolla, and animals of the Transport Train accumulated in great numbers, it became necessary to condense a large supply of water. About 200 tons of water were landed daily from steamers in the harbour by means of a wooden shoot, which conveyed the water to iron tanks, from which a long wooden trough was kept constantly filled.

The troops soon moved up country, and on the opening of the 6th mile siding on the railway, the whole of the Transport Train animals were moved to Koomaylee; thus the supply required from the condensers became greatly reduced. The allowance of water to every individual in Zoolla camp, officers, soldiers,

and followers, has been 1½ gallons daily per head, a by no means wasteful allowance, when the climate is considered.

A water supply for about 5,000 animals, and proportion of men, was provided at Koomaylee in December and January, but these numbers being greatly increased in March, it became necessary to increase this water supply. Force, suction, and chain pumps were set up at the wells, capable of watering 10,000 to 15,000 animals and 5,000 men, and long ranges of troughs were provided, rendering the watering of animals an easy operation.

Lieut. Le Mesurier, R.E.

Lieut. Le Mesurier, R.E., Assistant Field Engineer, came out from England specially to set up the new American tube wells and pumps, at the different posts. This energetic officer took charge of the whole water supply generally, and, with his assistants, inaugurated and carried out a very efficient system of water supply at each post, as far as Addigerat.

Lieut. Le Mesurier's creditable exertions have doubtless come under his Excellency's own observation, it only remaining, therefore, for me to bring to his Excellency's favourable notice the services of Lieut. Le Mesurier's assistants, Lieut. Clarke, R.E., Lieut. Sargeant, R.E., Lieut. Protheroe, M.S.C., and Lieut. Mainwaring, R.E., Assistant Field Engineers.

Lieut. Le Mesurier has favoured me with the following remarks upon the water supply between Addigerat and Magdala :—

"Beyond Addigerat no stores could be carried, and paved slopes were made into the Nullahs for the animals, Norton's tube wells supplying drinking water. Beyond Antolo four Norton's tubes and driving apparatus complete were carried on six mules as far as Lat; they were then, of necessity, left behind, and finally reached Magdala on the eve of our departure, enabling us, however, to obtain a supply of pure drinking water, after a want of it for sixty hours. The water was obtained from the following sources :—Lake Ashangi, measuring 3½ miles by 2½ miles, and 17 fathoms in depth, and possessing the peculiarity of having no outlet. The river Aryangua, rising at Lat, and said by some to be the source of the Taccazze. The Tellare river was crossed at Dildee. The Taccazze river was crossed at Meyn. On the Wadela plateau the supply was obtained from the Santara, Gosho, Gashoss, and Tanta rivers, running into the Jita. The Jita river, about 2,500 feet below the Wadela and Dalanta plateau, was dry on the advance of the army on the 4th of April, and nearly so on its return on the 23rd of April; the distance in a straight line, from one plain to the other, is not less than 3 miles, and to accomplish the journey, by the King's road, nearly 10 miles. Water was found in Dalanta plain in pools in the small valley. The formation here apparently was basaltic trap, while on the Wadela, it was sandstone. The Bashilo river, 8 miles north of Fahla, running knee deep after several severe thunder showers, was the only water crossed deserving the name of river. It was the main source of supply to the army when encamped before Magdala. The water in the small native wells, in the immediate vicinity of Magdala, was unfit for any purpose, owing to the number of dead animals, &c.; and the small supply obtained from the wells dug by the troops, though

clear, was of a peculiarly bitter taste. A medical officer assured me that it was not injurious."

Telegraph. Lieut. St. John's telegraphic operations have not come under my observation beyond the passes. I can, however, bear testimony to the value of the telegraph. I may say the telegraphic communication has been simply invaluable, and it has not failed when most wanted.

I have now to bring to His Excellency's notice, that the Engineer Park having had the advantage of being formed with great care in Bombay, under Captain Greig's direction, has always been enabled to comply with the requisitions made upon it. It has fulfilled its purpose completely, and therefore calls for no further remarks. Captain Greig has expressed himself well satisfied with the exertions of his assistants, Lieut. Sexton, R.E., A.F. Engineer; Cornet Dalrymple, A.F. Engineer.

Captain Greig.

In concluding this remaining portion of my report, it remains for me to bring to His Excellency's favourable notice the services of my Brigade Major, Captain Charles Goodfellow, V.C., R.E., Field Engineer, which have been so valuable to me, by reason of his energy of character and experience, in the conduct and management of public works.

R.E. and Sappers and Miners. Of the Royal Engineers, and Madras and Bombay Sappers and Miners, the undermentioned companies have been present with the force :—

10th Company Royal Engineers.

Madras Sappers and Miners—G Company, H Company, K Company.

Bombay Sappers and Miners—No. 1 Company, No. 2 Company, No. 3 Company, No. 4 Company.

The 10th Company, R.E., is divided into 1st, telegraphists; 2nd, signallers; 3rd well-borers; 4th photographers.

The telegraphists have been employed, between Zoolla and Antolo, only under the orders of Lieut. Pusey, and under the general superintendence of Lieut. St. John, R.E.

The signallers made themselves useful to the army the whole way from Senafe to Magdala, and their services were more especially valuable whilst the army crossed the ravines of the Taccazze, the Jita, and the Bashilo, and on the advance on Magdala, in communicating with distant points relative to placing guns in position. His Excellency is aware of the services of the officer under whom these men worked so willingly and efficiently.

The well-borers made themselves generally useful on the line of march, from Koomaylee to close to Magdala, proving the efficacy of the American pumps, as applicable to the line of march of an army. The operations of these men were judiciously directed by Lieut. Le Mesurier, R.E.

The photographers have completed a series of views from Zoolla to Magdala, illustrating all points of interest on the line of march of the army. It is to be regretted that rather more professional and artistic knowledge was not brought to bear on this subject; some beautiful effects of light and shade have been lost, owing to the views not having been taken at the proper time of day. Major

Pritchard, R.E., commanded the 10th Company, Royal Engineers, and was with the photographers throughout the expedition.

Madras Sappers. Major H. N. D. Prendergast, V.C., R.E., commanded the detachment consisting of G, H, and K Companies; Staff Officer with the detachment, Captain Foord.

The G Company has been posted at Zoolla and Koomaylee during the whole campaign. The services performed by this company on the public works at Zoolla, on the railway, and on the Koomaylee water-works, have been excellent. The Sepoys of this company excavated a well on the railway line, 85 feet in depth, without lining of any kind, and proved themselves very skilful workmen. I have much pleasure in recording the good services rendered by Lieut. Morris, commanding this company, in superintending the water arrangements at Koomaylee. These services have proved most beneficial to the Transport Train Establishment at that post. Lieutenants Protheroe and Mainwaring have been before mentioned.

The H Company has been employed during the whole campaign on the public works at Zoolla, and has been most industrious. This company has shown itself ever ready and willing to undertake any work required of it. Lieut. Pennycuick, R.E., commanding the H company, appears to have conducted the duties of his position in an efficient manner. Lieut. Cunningham, R.E., has been employed on detached duty at Antolo.

K Company.—This company commenced work in the Senafe pass, after a short stay at Zoolla, and afterwards, when joined by head-quarters, improved the track route between Antolo and Magdala, rendering it suitable for laden mules and elephants, and was present at the action of Arogee and taking of Magdala. Captain Elliott, N.I., commanded; Lieut. Bird being subaltern officer. Lieut. Coaker, R.E., was detached from the company on its arrival at Zoolla, and worked with the 4th Company Bombay Sappers, throughout the campaign.

Bombay Sappers and Miners. With head-quarters, Captain Macdonnell, R.E., commanding; Lieut. Merewether, R.E, adjutant. No. 1 Company arrived at Zoolla, in October, from Aden; after a short time this company was sent to the Sooroo defile, and worked on the roads, and passes, till December, when it marched to Senafe, and worked on the ghaut till the end of January; it was then removed on to Addigerat, working on the road between Senafe and Addigerat, more particularly on the Kersabba Ghaut, for which pieces of road great credit is due. The company then proceeded to Antolo, and was employed in constructing the telegraph, returning to the Sooroo pass in time to repair the damage done during the month of May, and remained there on duty till all the troops had cleared out. This company was commanded by Lieut. Newport, and I consider it did very efficient service under this excellent officer's command. Lieut. Osborne, R.E., was attached to this company in January, and subsequently performed the duties of adjutant, from January to May, during the time Lieut. Merewether was absent.

No. 2 Company.—This company arrived in this country with head-quarters,

early in December, and after a short stay at Zoolla, worked on the Senafe pass, and principally on the Sooroo defile, for which the company deserves great praise. The company was then pushed on to Antolo, and thence to Magdala, assisting in the road making, and were present at the action of the 10th, and capture of Magdala on the 13th April. Captain Sturt, R.E., commanded, and also worked this company, an arrangement which was most beneficial to the interests of the company.

No. 3 Company.—This company worked for two months at Zoolla, on the stone pier, the men being employed 8 hours a day; they were then removed up into the pass, and worked on the Senafe Ghaut, the work between Senafe and Addigerat, and between Addigerat and Antolo, assisted in road work between Antolo and Magdala, and were present in the action of the 10th, and taking of Magdala on the 13th April. Captain Leslie, S.C., commanded, and the company worked under the orders of Lieut. Jopp, R.E.

4th Company.—Worked two months at Zoolla, on the stone pier, 8 hours a day, was then employed at Lower Sooroo, and subsequently in the Senafe Ghaut, assisted in making the road between Senafe and Addigerat, and Addigerat and Antolo; also was employed generally in road making between Antolo and Magdala, and was present in the action of the 10th, and capture of Magdala on the 13th April. Lieut. Leacock, S.C., commanded this company, which worked under the directions of Lieut. Coaker, R.E.

Captain Macdonnell commanded the Bombay Sappers, three companies, and Major Prendergast, V.C., the K Company, Madras Sappers and Miners, during the action of the 10th April. Major Pritchard, R.E., being senior officer of Engineers with troops, commanded on the 13th at the capture of Magdala the following details: 10th Company Royal Engineers, K Company Madras Sappers, 2nd, 3rd, and 4th Companies Bombay Sappers, the distribution of Engineer officers and men being under Captain W. W. Goodfellow, second in command of Royal Engineers with the force.

(Signed) ST. CLAIR WILKINS,
Lieut. Colonel, R.E.,
Commandg. Engr. A. E. F.

PAPER XII.

SKETCH OF MAGDALA AND THE SURROUNDING COUNTRY.

BY LIEUTENANT T. J. WILLANS, R.E.

The accompanying sketch of the Magdala position was executed by pacing with a prismatic compass, during the few days our troops occupied that fortress. It includes two adjacent hills, Selassee and Fahla; or more correctly, these two with Magdala are three elevated spurs of the same mountain. Selassee is the highest of them, the scarp at the top of it being about 1,600 feet above the plateau below, and about 150 feet above Magdala. The latter is commanded by it, at a range of about 200 yards, but there are portions which are sheltered from direct fire on the south side, and screened from observation by a small hill near the church. Except by the "King's Road," and from Islamgee, Selassee is practically inaccessible. There are a few paths to it leading from the valley on the north side, which are used by the natives, but the ascent by them is so steep, and the track winds so often between precipices, where a few men, by rolling down stones, could destroy an army, as to render an ascent by them impossible, even by the lightest troops. The configuration of the ground is chiefly remarkable for the horizontal bands of scarped rock which surround the hills, dividing them into terraces. These natural scarps vary in height from 10 to 100 feet, and are most formidable obstacles. Fahla is crowned by one all round, from 20 to 50 feet in height. Its summit is a natural bastion of great strength, and in the centre of it there is a small elevation, commanding the whole of the interior, which is admirably adapted for a keep. It is considerably lower than Selassee, and also not as elevated as Magdala, although it is over 1,200 feet above the plateau below. The position in which the guns are shown is that in which they were placed on Good Friday. Afterwards some were moved from Fahla to Islamgee, and found at the latter place by us.

Upon our approach on the 10th of April, the Abyssinians swarmed down the "King's Road" from Islamgee, coming first into sight as they crossed the saddle, between Fahla and Islamgee. Here they divided into two portions, one continuing to descend by "Theodore's Road," coming into contact with the 4th King's Own Royal Regiment, and under the fire of the rockets of the Naval Brigade; the other rapidly diverging down the Arogee Valley, was opposed by

the 23rd Punjaub Pioneers and a battery of mountain guns. The baggage, which was slowly ascending the Arogee pass, was defended by the guard forming across the steep ravine at the head of it, so as to bring the Abyssinians under a cross fire, from which they suffered most severely.

Magdala, in its natural inaccessibility, is much stronger than either Selassee or Fahla. It is guarded by two scarps, the upper, a small one, varying from 20 to 70 feet in height, and the lower, or great scarp, a perpendicular wall of solid rock, in some places over 250 feet high. The only entrances to the fort are from Islamgee, by the Kokilbir, and on the south side by the Kaffirbir gates; the former by a rugged and inaccessible path, the latter by one which is even more precipitous and difficult. The plain at the top of Magdala is about 300 feet above Islamgee, and nearly the same height above the eastern spur, outside the Kaffirbir gate. On the Islamgee side, from which we assaulted it, there are two gates; the outer one is in a small outwork or orillon, which is 70 feet below the main position. The path from the lower to the upper gate is exceedingly steep, winding through the precipitous rocks, which form the upper scarp, and not even permitting two men to walk abreast along it. At the top it was closed by a doorway, about 3 feet 6 inches wide. The lower entrance was through a small double storied hut, built of stone and mud, about 10 feet square. The doorway was 4 feet wide, of stout timber, and over it there was a small window, in the upper story, no doubt constructed to enable the defenders to hurl stones and spears upon an assailant. A slight flanking fire in front of the gate was formed by short stone and mud walls on each side of it, but which, owing to their unscientific construction—the loopholes being only 5 feet above the ground outside—were of as much use to an enemy at close quarters, as to the defenders.

Along the face of the outwork or orillon, in which the lower entrance was placed, a stockade extended from the large scarp on the east, to that on the west side, and effectually closed the accessible portion of the hill from Islamgee. It consisted of a stout wall, built of dry stone, into which were inserted, horizontally, branches of trees. As the latter were weighted by the top portion of the wall and were about 7 feet above the ground, outside the stockade, a most impenetrable obstacle was formed. The same arrangement was adopted along the crest of the hill at the second gate, and also at the Kaffirbir side of Magdala. Although the defences were rudely constructed, and would not have stood even against field artillery, they were admirably adapted for resisting the attack of an enemy armed only with muskets and spears, for which purpose, no doubt, they were originally constructed. They were rendered also much more formidable by the outworks, in which the lower entrances were constructed, being entirely seen into and commanded from the second line of stockades in which the upper gates were placed. The stockades could, however, have been easily burnt by an enemy, as the wood was very dry, and the fire, when once lighted, would have spread rapidly. The great drawback to the ability of Magdala to stand a siege was the want of water. There were a few wells on the top of the hill, but at the time of our occupation they scarcely yielded a gallon of water each in the

hour. On the north side of Selassee water was obtained in very small quantities, and in the country below, between Magdala and Fahla, there were several wells. Theodore had recognized this weakness and had commenced to excavate tanks on the hill, but they were not completed, nor of any service in collecting water.

On the 13th of April two mountain batteries were concentrated at (A), the Armstrong 12 pounder battery (4 guns) at (B), and two 8 inch mortars were placed behind the ridge, between Fahla and Selassee. After a simultaneous firing for about half an hour at the Kokilbir gate, the assaulting column was formed in rear of the mountain guns, headed by a portion of the 10th company, Royal Engineers, under the command of Major Pritchard. Just previous to the assault being ordered, Captain Goodfellow, the senior Royal Engineer officer, told Sir Robert Napier, K.C.B., that although the barrels containing the powder had arrived, the powder bags were still behind.* The Commander-

* The following memorandum, written by Lieut.-Colonel Pritchard, R.E., by request of Lord Napier, explains the reason of the non-arrival of the powder bags at the same time as the powder, a subject that was much commented upon by the correspondents of the various newspapers.—Ed. :—

Memorandum.—About 8 30 on the morning of Monday, the 13th April, 1868, in accordance with orders received, the 10th Company of Royal Engineers, and one company of the Madras Sappers and Miners, marched from their camp on the Affigi plateau towards Magdala. In addition to intrenching tools, they took with them two escalading ladders, two small barrels of powder, some fuze (resembling that of Bickford's), and six powder bags made from the native mussocks or leather water bags. According to the orders of Captain Goodfellow, Royal Engineers, the two barrels of powder were placed on a mule, one on each side of an Otago pack-saddle, with the powder bags and fuze between them.

The above force (joined by two companies of the Bombay Sappers and Miners, who were placed under my command for the day by Captain Goodfellow, R.E.), advanced at 9 a.m up King Theodore's road, in rear of two companies of the 33rd Regiment. When they had nearly reached the saddle of land joining Selassee and Fahla, they, by orders received from Sir C. Staveley, K.C.B., moved off the road to the left, directly under the high cliff bounding Selassee and about two miles, I should think, from our camp on the Affigi plateau.

Before ascending the crevice in this cliff, I received orders from Sir C. Stavely to leave the ladders, powder barrels, bags, &c., at the foot, and to move forward as an advance guard, which I accordingly did. We went up the crevice and climbed up the steep and almost precipitous cliff, inaccessible to horses or mules, passed through the enemy's camp, marched round to the left of Selassee, and approached Magdala in skirmishing order, there being several of the enemy's cavalry riding about in front of the gateway.

About 2 p m., when it was decided that Magdala should be taken by assault, I received orders to send back for the ladders, powder barrels, bags, &c. I accordingly sent a detachment, who brought up the ladders, the two barrels of powder, and fuze, but not the powder bags, which, on enquiry, I found had been taken by the natives for their original purpose of carrying water. I reported the circumstance to Sir C. Staveley, and informed him that I could, if necessary, blow open the gate of Magdala with one of my barrels of powder and fuze. About 4 p.m., the Engineers took the post of honour, carrying our intrenching tools, ladders, two barrels of powder, fuze, &c., and led the way along a path on the side of a precipice to the gate, on the right of which, over the wall we effected an entrance by climbing and using our ladders. On our entrance, I told off Lance Corporal McDonagh to assist in removing the huge blocks of stone which had completely blocked up the porch in rear of the gateway. Had I attempted to blow open the gate with the powder in my possession, the troops who forced their way up in rear of us would have been blown over the precipice.

The gate was at the entrance of a porch 15 feet square, and this porch was entirely filled from immediately behind the gate with huge blocks of stone, so that the gate would only have been shattered by the powder, the stones behind it remaining as an impenetrable obstacle to an entrance, and, therefore, the application of powder would have been utterly useless.

G. D. Pritchard, Major, Royal Engineers.

in-Chief had, however, determined not to use them, and the troops marched up the steep path to the gate in fours, the sappers in front, with crowbars to force an entrance. When the gate was reached it was found absolutely untouched by a single shell, and uninjured. The interior of the doorway was half filled with stones, which prevented its being opened by crowbars, and during the time which necessarily elapsed in bringing up and placing ladders against the side of the gate, the 33rd regiment had effected an entrance.

The surprising fact is that the concentrated fire of so many rifled guns at an open target—for the gate was not screened in the least—should have effected so little; but the ranges in all cases were too great to be effective. The mountain batteries were not advanced, as might easily have been done, in order that they should continue firing over the heads of the storming party. The day after I carefully searched the northern portion of Magdala to see the effect of the Artillery fire, but beyond the scoring on the face of the rock and some trifling damage done to the stockades, there was little evidence of the firing of the previous day. One 7 pounder shell had made a hole in the lower stockade, through which a man could crawl with difficulty, and this had been used by the 33rd regiment in the assault.

On the 17th of April Magdala was burned to the ground, and the Kaffirbir and Kokilbir gates blown up. The destruction of the latter was very simple, a barrel of powder in each case being placed in the interior of the entrance, covered by a heap of stones and ignited by Bickford's fuze. All the buildings on the hill, being made of wickerwork and thatched, burnt with the greatest facility, and the stockades were rapidly consumed, showing how very difficult it would have been for the defenders to preserve them if they had been set on fire by shells.

T. J. W.

PAPER XIII.

NOTES ON A TRIP TO PRUSSIA IN 1868.

BY COLONEL WILBRAHAM LENNOX, R.E., V.C., C.B.

The troops of the North-German Confederation are instructed in the duties that have to be performed by an army during active operations in the field, by means of manœuvres carried on in different parts of the country in the autumn, the previous part of the year having been devoted to company and battalion drill.

The law of the land permits these manœuvres taking place over any ground, and provides that all damage done shall be paid for, the value being estimated by a committee composed of civil and military officers of the district. The manœuvres usually take place after the principal part of the crops has been gathered in, and the claims for damages are generally moderate, which is probably owing to Prussia being a military nation, and to the proprietors themselves having been in the army, or, at all events, having very near relations in it.

For some of these manœuvres only a brigade can be assembled, but often a division or an army corps, and, occasionally, even larger bodies of troops are brought together. The object of the manœuvres is to afford practical instruction to all, and, therefore, all the services and departments take part in them. The troops assembled are generally divided into two forces, which are manœuvred against each other under the command of two officers selected by the General directing the manœuvres. Field officers are detailed daily as judges, and they, from time to time, as circumstances require, decide which party, being at a disadvantage as regards numbers or position, should give way; the decision of a judge, even though he be a junior officer, is instantly attended to.

At the close of each morning's manœuvres, the whole of the mounted officers (all captains are mounted in the Prussian Army) are assembled, and the directing general criticizes the day's proceedings, freely pointing out the errors committed, even by the commanders. After this very instructive *kritik*, the officers return to their corps, and the two opposing forces take up positions for the night, posting piquets and throwing out sentries and videttes, as they would do on active service. The troops then make their cooking places, cook their rations, and prepare their bivouacs; tents are never issued on these occasions, in fact, it appeared to be the general opinion that in future continental wars, armies will never be able to move with tents.

On the following morning the victors advance, feeling for the retreating enemy, who has probably fallen back and taken up a stronger position, from which he is dislodged, if possible; and thus each day is devoted to giving as much practical knowledge of war as can be given during peace.

The General commanding the army-corps usually deputes a General to direct the manœuvres, but he himself attends and is enabled to judge of the capacities of the General and commanding officers; and the superior officers, generally, are able to ascertain who are deserving of advancement, and who are unfit for promotion.

During the autumn of 1868, the 8th, or Rhine-Provinces Army-Corps, whose head-quarters are at Coblenz, had small manœuvres for 3 regiments, 2 squadrons, and 2 batteries, near Coblenz; and larger manœuvres for 12 battalions, 10 squadrons, and 6 batteries between St. Wendel and Saarlouis.* The Engineers did not take part in these manœuvres, as they were required for the siege operations at Coblenz.

By means of these annual manœuvres, all the services in the Prussian army are instructed in the duties required from them during active operations in the field But the Prussians are not unmindful that armies may be called upon to lay siege to, or defend fortresses; they are not, moreover, satisfied with their Engineer soldiers learning to sap and to mine, &c., and, with their Artillerymen, being taught to mount guns in battery, &c., but they recognize the fact that a great deal of most valuable instruction is gained by the several services performing these duties together and as they would do on service, and they, therefore, from time to time, carry out on a large scale siege operations in which Artillery and Infantry co-operate with the Engineers, both in the attack and defence of a fortress. Accounts of some of these siege operations are given in the following books:—"R.E. Corps Papers," Vol. X, Operations at Juliers in 1860; "R.E. Corps Papers," Vol. XII, Operations at Graudenz, in 1862; "Professional Tour of R.A. Officers, in 1865", Siege of Neisse, in 1865.

I was ordered to attend the operations which were undertaken at Coblenz, during the autumn of 1868; in these operations, the following troops took part:—

Engineer Soldiers or Pioniers.

The 4 Companies of No. 8 (the Rhine) Battalion, quartered at Coblenz.
2 (Sappeur) Companies of No. 7 Battalion, from Coln.
2 (Sappeur) Companies of No. 10 Battalion, from Minden.
2 (Sappeur) Companies of No. 11 Battalion, from Mainz.
1 Company (No. 2) of the Baden Pioniers.

Total—11 Companies of Pioniers.

Artillery.

5 Companies of the 2nd Division of the 8th Regiment of Garrison Artillery, quartered at Coblenz.
1 Battery (1st 6-pr. Batt.) of the 1st Div. of the 8th Reg. of Field Artillery, from Coln.
1 Battery (5th 4-pr. Batt.) of the 3rd Div. of the 8th Reg. of Field Artillery, quartered at Coblenz.

Total—5 Companies and 2 Batteries.

* An account of this manœuvre, by Major W. H. Goodenough, R.A., has just been printed at the Royal Artillery Institution, Woolwich.

Infantry.

3 Batts. of the 4th Reg. of Grenadier Guards, quartered at Coblenz.

2	,,	(1st & 2nd)	of the	29th	Regiment	of Infantry,	quartered at Coblenz.
1	,,	(3rd)	,,	29th	,,	,,	from Simmern.
2	,,	(1st & 2nd)	,,	68th	,,	,,	quartered at Coblenz.
1	,,	(3rd)	,,	68th	,,	,,	from Julich.

Total—9 Battalions of Infantry.

I give a short account, with journal, of the siege of Fort Alexander, Coblenz, and also extracts from such of the reports of Lieutenants E. D. C. O'Brien and C. H. C. Halkett, R.E. (who were sent with me), and of Lieutenant W. B. Hurst, R.E. (who came over to Coblenz on leave), as I consider likely to be interesting to our brother officers.

In the Prussian army the whole of the Engineer soldiers are called "pioniers," while the words "sappeur," "mineur," and "pontonier," are only applied to the men who are specially taught to sap, mine, and pontoon, respectively. I have, therefore, used their words instead of our own general word "sapper." For the composition of a battalion of pioniers, see Appendix A.

The Prussians have now laid down in their regulations the disposition of troops detailed as covering party and guard of the trenches; an abstract of these regulations is given in Appendix B. It is, I think, interesting to know what other nations do, especially when there is nothing laid down in our own regulations on this subject.

The Prussians have some peculiar arrangements as regards the formation of working columns, and particulars are, therefore, given in Appendix C. They also trace parallels, etc., somewhat differently from us, as will be seen from Appendix D.

In the Prussian army, siege-batteries were formerly thrown up by the Engineers, but now they are constructed by the Artillery, who do not seem to relish the work much; they have not yet adopted any changes in consequence of the introduction of more powerful artillery; they appear to overcome somewhat the difficulty of getting the cheeks of embrasures to stand, by making them wider (viz. $2\frac{1}{2}$ or 3 feet) than we do, and also by making them more shallow, by using a gun-carriage that can fire over a sill 5 feet high. The advantage of having an embrasure that is not so easily damaged by the fire of its own gun is, I imagine, more than counterbalanced by the greater liability of the gun being disabled by slant fire owing to its being raised up so high.

Some notes on the construction of Prussian siege-batteries are given in Appendix E. I think their anchor fascines are good; and that there may be something to be learnt from their mode of laying platforms, and, perhaps, from their musket-proof shutter for embrasures. Their batteries were thrown up quickly, but they employ a good many men and place them much closer to each other than we dare do, or than they could do without having the place illuminated by lanterns which we consider to be inadmissible. I saw on one occasion six men working in a length of 9 feet, that is, the men were actually nearer to each other than when standing in the ranks.

The half-sunken battery, used by the Prussians, is supposed, according to their regulations, to be completed in one night, and to be ready to open fire by the morning, and certainly, in one case, we saw the platforms were laid and the guns were in battery by the morning, but the parapet was not of the full dimensions, nor were the tongues of earth between the several gun-platforms dug out, nor was the magazine finished; the battery could, without doubt, have opened fire after a fashion, but the advantage of being able to open fire from a battery, before it is in perfect order, is, I consider, a very doubtful one. I imagine that the guns in such a battery would be worked at a very great disadvantage, and would probably shortly be silenced by the fire from the fortress.

The Prussian saps are described in Appendix F, and the effects of fire from muskets, wall-pieces, and artillery, against four different kinds of sap, are recorded in Appendix G. The old kneeling sap did not come at all badly out of the trial; the men working it were not wounded by the musketry or wall-piece fire, and no sap was pushed more rapidly: it was certainly shut up by artillery fire, but I had always understood that it was an admitted fact that sapping could not be carried on against Artillery fire; it must be born in mind also that the guns used against it were 12 pdrs., whereas those used against Colonel Leuthaus' sap, and the Austrian sap, were 4 pdrs. and 6 pdrs. only. I would call attention to the Austrian sap, which is 6 feet deep, and could therefore, I consider, be worked regardless of Artillery fire, for I cannot agree with the opinion expressed in the article on the great "Sappeur-Uebung," of 1868, in the Militärische Blatter, of November 1868, that "it undoubtedly seems scarcely possible, even with the most perfect cover, to allow, during the day time, the sapper to advance, step by step, for the moral effect of a shell bursting in the parapet, although, perhaps, harmless, must be so great that it would be difficult to keep the men at their work." This appears to me to be entirely erroneous, and not complimentary to Sappers, who, I trust, would not leave their sap-head any more than Artillery would leave their battery, from the moral effects of shells bursting, not only in the parapet, but in the battery itself. Parties, either of Sappers or of Artillery, would not, we may hope, be driven from their posts by the number of casualties, much less by the moral effect of harmless shells, but would continue their respective duties until ordered to desist by superior authority.

The Prussians appear to plant trees and brushwood on the glacis of their forts; the plan has two great recommendations: 1st, when a place is being prepared for a siege, timber and brushwood are much required; and, 2ndly, when a place is being besieged, roots on the glacis hinder the besiegers from pushing their saps as rapidly as they otherwise would.

Field Marshal Sir J. F. Burgoyne has always advocated the importance of a wall-piece for siege operations, and a paper on the subject, in his Military Opinions, gives the requisites for such a piece. The Prussians have in their service a wall-piece which embraces many of those requisites. In Appendix H is given a slight account of this wall-piece, and of the results of the practice witnessed with it. The advantages of a wall-piece are admitted to be very

great; officers, who have been engaged in the attack of any place, generally agree that they would be most useful, and that they would be even more useful for defence.

The mining was very satisfactorily done, and notes on the subject are given in Appendix I.

In Appendix *J* is given an account of some experiments against iron palisades; the palisade would have stood a better chance if it had been placed in a wider ditch.

The Prussians, at the commencement of a siege, detail a captain or field officer of Engineers, for permanent duty as "major of the trenches;" I was unable to find out the exact duties he has to perform, but I believe they are very nearly the same as those detailed in Appendix K, which is from the Austrian regulations.

The passage of a wet ditch must always be a very difficult operation; a description of the plan adopted by the Prussians in the wet ditch at Ehrenbreitstein, is given in Appendix L.

Officers anxious to obtain information relative to the composition, drill, etc., of the Prussian army, are recommended to refer to Heerwesen and Infanteriedienst der Königlich Preussischen Armee, by Major General Witzleben: Berlin, 1868. Also to Hand - und Taschenbuch für die Infanterie-Offiziere der Preussischen Armee, by Lieutenant and Adjutant Lehfeldt: Berlin, 1867. There is also a book, published at Berlin in 1861, called "Allerhöchste Verordnungen über die grösseren Truppenübungen."

The above, and the Engineer drill books (mentioned at Page 170) can be purchased; Messrs. Asher, booksellers, of 13, Bedford Street, Covent Garden, have a shop at Berlin.

Our stay of about six weeks at Coblenz was rendered very pleasant by the kind and hospitable reception accorded to us by the Prussian officers, of all ranks and services, whom we had the pleasure of meeting.

His Excellency, General von Herwarth, commanding the 8th Army Corps, gave us every assistance, and kindly permitted us to be present at all the "*kritiks*" on the manœuvres and siege operations.

Lieutenant-General von Uechtritz, Inspector of the 4th Artillery Inspection, Colonel von Kameke, the commander of the 8th Artillery Brigade, and the officers of the sister corps, gave us all the facilities we required.

But although we were received by all the Prussian officers with consideration and kindness, nothing could equal, much less exceed, the cordiality and attentions that were bestowed upon us by His Excellency Lieutenant-General von Kameke, the Inspector General of Engineers, individually, and by the whole of the officers of the Prussian Engineers. Colonel Leuthaus, who directed the operations, gave us every assistance, and caused us to be furnished daily with a copy of the orders. We were made honorary members of the Engineer mess, and were treated quite as "camarades;" it was not *mere* civility that we were shown, but many of the officers (at a time when it must be remembered they

had hard work), put themselves to great trouble and inconvenience to assist us and shew us attention; as there were so many Prussian Engineers at Coblenz for the operations, it would be impossible to mention all to whom our thanks were due, but I cannot refrain from naming two who were able, by their great knowledge of English technical words, to render us very material assistance, viz., Lieutenant Hoffmann, (adjutant to Colonel Leuthaus), and Lieutenant Steindorff, both of the Engineers.

I dwell particularly on the civility that we, as British officers, received, in order that our brother officers may remember it when they meet foreign officers.

There were many foreign officers at Coblenz, besides ourselves, viz., Engineers from Austria, Baden, Bavaria, Hesse, Russia, Saxony, and Wurtemberg; Artillery officers from Baden, Bavaria, and Saxony; and an Austrian cavalry officer. Many of them also were most obliging.

W. O. L.

SIEGE OF FORT ALEXANDER, COBLENZ, IN AUGUST, AND SEPTEMBER, 1868.

Preliminary Remarks.

The front selected for attack was the south, as the government ground was most extensive in that direction.

The operations were conducted in almost all respects as they would have been in an actual siege; the works were for the most part continued day and night, Sundays excepted. Some portions of the parallels and batteries were only traced, not executed, as their construction would have spoilt the drill ground of the garrison. In the operations on the night of the 19th of August, the movements of the troops and field batteries were restricted to the government ground, and those fields from which the crops had been carried.

Plates I. and II. give the siege works executed, traced, or simply projected: the shape of Fort Alexander is purposely given incorrectly, as foreign governments have naturally very great objections to plans of their forts being published.

The covering troops and the guards of the trenches were not kept out day and night; they came on duty about an hour or so before dusk, and were then posted according to their regulations for the "day disposition," and when it became dusk, they were moved into the positions assigned for the "night disposition." (For these dispositions, see Appendix B, and Plates III, IV, V, VI.) About 10 p.m., or after all the sorties contemplated had been made, the troops detailed as covering party and as garrison returned to their barracks.

From $2\frac{1}{2}$ to 4 battalions of infantry were generally told off daily to represent the garrison, and one or more sorties were made every night at the commencement of the siege, and as long as the infantry took part in the operations; these sorties are not always mentioned in the journal of the siege. The troops when advancing to repel a sortie, always did so with drums beating, which appeared to be of doubtful advantage.

The garrison occasionally illuminated the ground, in order to discover the working parties. The means adopted were the Drummond light, rockets, and light-balls. As it would have been dangerous to fire the latter, they were carried by the artillery of the garrison to the place where they ought to have fallen, and were lighted when the mortars by which they were supposed to have been thrown, were fired. We have not given any detail of the work performed by the garrison, as we did not visit the interior of Fort Alexander regularly; we thought it better not to go into any of the forts unless accompanied by a Prussian officer. The garrison made a few mortar batteries, some of them in the ditches, but did not do anything particularly worth noting.

The strength of the working parties is not always given in the journal, as there were occasionally great discrepancies between the number of men and the amount of work done, which would only have confused readers. The infantry were always detailed by whole, half, or quarter battalions, and never by numbers. Any pioniers there were to spare any day, after all the engineer duties of tracing, superintending, etc., had been provided for, were employed as infantry in throwing up the parallels, etc.

After the commencement of the regular saps, on the 27th of August, a few infantry were always posted in the most advanced positions of the fortress, to watch each sap-head, and to fire a round of blank ammunition whenever one of the sappeurs was seen; the plan is very useful.

A general plan of the attack, with a disposition, shewing the daily duties for each arm of the service, both in the attack and defence, during the siege, was published before-hand for general information, and, subsequently, detailed daily orders were issued, for the attacking and defending troops respectively. These orders detailed the strength of working parties, and gave general instructions, but the exact hour and management of the sorties, and the manœuvres of the covering troops to repel them, were left entirely to the discretion of the commanding officers. Any actual collisions between the two parties were prevented by the judges; these judges are field officers specially detailed, they wear a distinguishing badge, (viz., a white scarf round the arm) and their decisions as to which troops are to retire, &c., are considered final, and must be obeyed instantly, irrespective of all question of seniority. If the commander of a sortie succeeded in placing at any point a larger force than was opposed to him at the moment, the working parties had to retire, and the trenches were demolished, if time admitted of it, before the sortie itself was forced to retreat by the advance of the reserves.

A captain of Engineers was detailed as "major of the trenches" for the whole siege.

The officers detailed by name in orders daily were as follows:

For the attack.

1 Field Officer of Infantry as commandant of the trenches.
1 Captain of Engineers, in charge of engineer operations.
1 Captain of Artillery, in charge of artillery operations.

For the defence.

1 Field Officer of Infantry, as commandant.

1 Captain of Engineers, in charge of engineer operations.

1 Captain of Artillery, in charge of artillery operations.

The above officers were on duty for 24 hours, and their time of relief was one hour before the arrival of the troops, that is to say at 5 p.m.

The number of engineer officers on duty daily varied of course with the amount of work to be superintended; the hours of relief were, captains at 7 p.m., 3 a.m., and 11 a.m.; lieutenants, at 8 p.m., 4 a.m., and noon.

The captains were allowed to leave the trenches to write their reports, but the lieutenants were required to be with their parties the whole time. The pionier reliefs were at 6 p.m., midnight, 6 a.m., and noon; but the brigades were allowed to leave the trenches as soon as their tasks were completed. The whole of the operations were conducted under the immediate orders of Colonel Leuthaus, Engineers, Inspector of the Third Pionier Inspection.

Journal of the Siege.

The front selected for attack was the south front, before which there is a large plateau called the Karthause; this plateau, which is almost level for about 1200 yards in front of the fort, becomes very much narrower, and terminates suddenly in some steep ravines, the crests of which are called the Laubach position. These ravines and the rising ground beyond, for a considerable distance, are covered with wood, and consequently were very favourable for masking the movements of the troops employed in the attack.

The garrison occupied as advanced posts on the Karthause plateau the small bastioned field work, called the Engineer Practice Fort, about 600 paces to the left front, and also the rifle butts, about 1200 paces to the right front: these advanced posts, although of no strength in themselves, were very useful in giving cover to a considerable force that the garrison had out to support their sentries and piquets which were watching these ravines.

19th August. It having been determined to capture the rifle butts and practice fort, on the 19th of August, the troops detailed for the attack, were, during the afternoon, brought under cover of the woods to the bottom of the deep ravine at the foot of the Laubach position.

Shortly before dusk the troops advanced rapidly against the rifle butts, covered by skirmishers and the fire of two field batteries that came into action at the edge of the wood, near the Simmern Road.

A simultaneous movement wasa lso made against the practice fort; but the advance, after driving in the outposts, was exposed to such a very heavy fire from the practice fort, that it fell back until it was sheltered by the crest of the hill, at about 200 paces from the work, and was there reformed.

In the mean time, the rifle butts had been carried, and as soon as that happened, the field batteries moved up rapidly, and took up a position where they were sheltered by the rifle butts from the fire of the main work, to which they had previously been exposed: the batteries now opened fire on the practice-

fort, and some of the troops that had been employed against the rifle butts were sent to assist the right column, in a renewed attack on the practice fort, which which was then successfully stormed.

The pioniers who accompanied the assaulting columns, immediately intrenched the positions gained; they cut banquettes out of the exterior slopes of the bastions and ravelin of the practice fort, &c.

The superior officers of engineers and artillery reconnoitred the ground in advance, under cover of advanced piquets, and decided on the positions of the first parallel and the batteries to be thrown up on the same night.

The garrison, during the night, made two sorties in force, but were driven back into the fortress, and the troops retained the position they had gained.

20th August. During the day, three companies of pioniers, and detachments of artillery were employed in arranging the tools and material at the depôts, to be ready for the working column.

The troops for the night's work paraded two hours before sunset, in the following order, in front of the depôts.

1st—Covering Troops.

3 Battalions of Infantry in marching order.

2nd—Tracing Party.

1 Company of Pioniers for the parallel and communications.

Detachments of Artillery to trace the Batteries.

3rd—Working Parties.

5 Companies of Pioniers.

3 Batteries of Siege Artillery.

2 Battalions of Infantry.

The whole of the tracing and working parties paraded in working dress, with havresacks and water bottles, and arms slung and three rounds of ammunition carried in the men's pockets. At dusk the covering troops were marched into the positions assigned to them, during the construction of the first parallel (Appendix B); and the first parallel, and communications from the rear were traced according to the Prussian regulations. As soon as the tracing was completed, the working parties were extended along such portions of the parallel and communications as were to be executed. The length of parallel, etc, traced was 1680 yards, and the length actually executed was 295 yards. When the advanced sentries had been posted, parties of pioniers marched out and dug rifle pits for them.

The Artillery traced and constructed four batteries, viz.:—

No. I, an elevated battery for three 25 pr. mortars; this was constructed in the ditch of the Practice Fort.

No. II, a sunken battery in the ditch of the Practice Fort for 2 guns to breach the masonry keep of the outwork, Gross Furst Alexander.

No. III, a half-sunken one for 4 guns, some distance in rear of the parallel.

No. IV, an emplacement at the extreme left flank of the parallel, for two field guns to fire en barbette. This battery was of very slight profile, and was only intended for use during sorties, the guns being run back into the parallel in the day time.

(For details of construction of batteries see Appendix E.)

The garrison made a sortie, but they were repulsed, and did not interrupt the working parties.

21st August. By day the parallel and communication were widened, steps were formed over the parallel, in places, and the artillery completed the construction of No. 1 battery, begun last night. Length of trench widened, 295 yards. At night, the covering party was represented by three battalions of infantry, who were posted according to the regulations on the subject.

The approaches to the second parallel were traced at dusk, by parties of pioniers. Those on the left only were thrown up. The length of trench traced was 673 yards, and the length executed was 360 yards.

The garrison illuminated the glacis with rockets, light balls, and the Drummond light, and made a sortie.

22nd August. *Day.* The approaches to the second parallel were widened during the day 360 yards. Detachments of pioniers were also employed arranging the tools and materials.

Night. At dusk the covering troops (represented by $3\frac{1}{2}$ battalions of infantry) were posted according to the regulations, for the opening of the second parallel; and the second parallel was traced as soon as possible.

The working party was brought up at once, and the portion of the parallel that was to be execute dwas commenced by flying sap. (See Appendix F.) The garrison made a sortie in force. The length of parallel traced was 723 yards, and the length executed was 217 yards.

23rd August. No work, being Sunday.

24th August. *Day.* The portion of the second parallel, commenced last night, was widened, and it was stepped in places.

Night. At dusk, after the covering troops ($3\frac{1}{2}$ battalions) had been posted, the approaches up to the positions of the demi-parallels were traced; the artillery also traced some batteries in the second parallel.

The approaches on the left were executed by flying sap: length 520 yards. The garrison made a sortie.

25th August. *Day.* The approaches, commenced last night, were widened.

Night. Two demi-parallels were traced and commenced by flying sap. The garrison made a sortie in force, accompanied by pioniers, drove in the piquets and supports, and got as far as the second parallel, part of which they destroyed, overturning about thirty gabions into the trench. The main body of the covering party had to be brought up before the sortie was repulsed. The work was much interrupted, as the working parties had to retire, but they resumed work again, as soon as the sortie was repulsed. The length of demi-parallel executed was 433 yards.

26th August. *Day.* The demi-parallels, commenced last night, were widened out. It being no longer possible to advance by flying sap, preparations were made for commencing work at dusk with the regular sap.

The Artillery arranged their materials for a mortar battery, to be commenced this night.

Night. Two ordinary saps were broken out from the demi-parallels; that on the left was henceforth called the left approach, and the other the central approach; the right approach was only projected, not executed. The artillery converted the right portion of the left demi-parallel into a battery for three mortars. The length of sap pushed was 30 yards.

27th August. The two sap-heads were steadily advanced. By day, by the Turkish sap; and by night by the ordinary single sap, and occasionally by a small piece of flying sap. (For details of saps, see Appendix F.)

28th August. The two saps were continued, that on the left now crowning the glacis of Gross Furst Alexander.

29th August. The central approach had now advanced to a point where it was necessary that it should change direction to the left; but as in this new direction it would be taken in reverse from Gross Furst Alexander, it was ordered not to be advanced any more until that outwork had been taken. On the left a sap was broken out to the right, crowning the glacis, and forming a demi-parallel.

30th August. The demi-parallel was continued during part of this day (Sunday) as the sap had not advanced quite so rapidly as had been expected.

31st August. The saps on the left were continued. A shaft was sunk in the demi-parallel on the glacis of Gross Furst Alexander, and a gallery driven from it, in order to lodge a charge which should blow down the counterscarp, so as to mask the loop-holes in the block-house flanking the ditch, and also to form a ramp by means of which the assaulting column could rush over the palisades in the ditch. A second gallery was driven a little to the left of the other, for the purpose of placing a charge under the parapet of the demi-parallel, the blowing away of which would greatly facilitate the passage of the troops from the demi-parallel into the ditch of the work; with the same object portions of the demi-parallel were stepped. The shaft and galleries were executed by non-commissioned officers and men of the mineur companies of pioniers.

1st September. The large mine (which had a line of least resistance of fourteen feet) was loaded with 275lbs., and the other with 25lbs. of powder, and both were tamped. A splinter proof was made about fifty feet from the shaft, for the protection of the officers firing the mines. At dusk the outwork, Gross Furst Alexander, was supposed to be well shelled, and the mines were fired by Lieutenant Tawell. The position and charge of the large mine had been exceedingly well calculated, and it produced exactly the objects desired. The loopholes of the blockhouse were perfectly masked, and the palisade was partly broken, and a ramp formed against the rest of it. The outwork was then successfully assaulted. Two companies of Pioniers, who accompanied the column, cleared away part of the palisading in the ditch, made a lodgment along the rear of the work, and commenced a communication between the ditch and the demi-parallel. The garrison made a sortie, and

endeavoured to retake the work, but failed to do so. The central approach was proceeded with as soon as the assault of Gross Furst Alexander had been commenced.

2nd September. The remainder of the palisades in the ditch of the outwork were removed. The communication into the ditch, and the lodgment were completed. The approaches on the centre and left were both pushed forward as rapidly as possible.

3rd September. The approaches were both continued, and reached the crest of the outer glacis, which was the position selected for the third parallel. The right approach, which was not executed, was supposed also to have reached a corresponding position.

4th September. The third parallel was commenced by six sap-heads; viz., two (one to the right and one to the left) from the heads of the three approaches, left, centre, and right.

5th September. The third parallel was continued, and an approach was made from the left of it towards the salient.

6th September. No work, being Sunday.

7th September. The saps were continued, and another sap-head was broken out on the left.

8th September. The saps on the right and left were advanced, and two new saps were broken out of the third parallel, to enable an advance to be made on the centre, blockhouse No. II.

9th September. The approach on the left centre had to be continued by a blinded gallery down to the lower level, within the outer glacis. The other saps were advanced, and another was broken out on the left, crowning the covered way, in front of the blockhouse at that salient.

10th September. The five sap-heads were advanced; that working from the left towards the centre being carried on by means of the crowning sap (See Appendix, F.)

11th September. The several saps were continued; those from the right centre and left centre meeting opposite blockhouse No. II, when the sap was continued straight towards the blockhouse, by means of the Wurfel or cube sap.

12th September. The saps were continued; those on the extreme right and left, by Turkish sap; that in the centre, by cube sap; and the other, by crowning sap.

13th September. Being Sunday only a little work was done, morning and evening, at those saps which were backward.

14th September. The saps on the extreme right and left having been pushed as far as was intended, they were only widened out. The sap on blockhouse No. II was continued by double sap until it reached nearly up to the crest of the glacis, where it was continued right and left by crowning sap. The other sap was continued by crowning sap. A trench was also made by single sap from the cube sap towards the right; this trench was made to drive

galleries from, for the purpose of placing two large charges to form lodgments; these mines could not have been made in the positions they would have occupied in an actual siege without considerable damage to the works and buildings of the fort.

15th September. The three crowning saps were continued. On the left a great gallery of descent was commenced. A common sap was also driven in front of the left centre of the third parallel. Two galleries were also commenced for the mines on the right.

16th September. The three crowning saps were continued, and the two on the left met. The left centre approach was continued. The great gallery and the two common galleries were continued; difficulties were experienced in both these common galleries; in the right, or No. 1 gallery, water was reached; and in the left, or No. 2, an enormous block of stone was met with, round which the gallery had to be driven. Preparations were commenced for converting the part of the crowning sap on the right of blockhouse No. II into a two-gun battery, to silence the guns flanking the right face of the Ravelin, and with this view the detached traverse there was removed.

17th September. The right crowning sap, the great gallery of descent, and the two common galleries were continued. A shaft was sunk in the trench in rear of No. 1 common gallery, to drain the water from it. The removal of the traverse and the construction of the battery were continued.

18th September. The right crowning sap, the great gallery of descent, and the two common galleries were continued, as also was the shaft to drain No. 1 common gallery. A small gallery of descent into the ditch of the Ravelin was commenced. The battery was proceeded with and the embrasures were sapped out, a light description of sap-roller being used for the purpose; musket-proof shutters were placed in the embrasures (see appendix E.), and the guns were got into battery.

19th September. The right crowning sap and the galleries of descent were continued. Two charges, each of 1,800 lbs. of gunpowder, were lodged about 45 feet apart, in chambers, at the end of two common galleries, and the galleries (66 feet) were tamped. These two mines were fired this afternoon; their lines of least resistance were 13 feet each, and the charges were calculated to produce four lined craters, or craters 52 feet in diameter; the results were very nearly as calculated, the craters being about 54 feet in diameter.

The enormous stone (which had necessitated the direction of No. 2 gallery being changed on the 16th September), was hurled to a distance of nearly 40 yards. A lodgment with gabions was formed on the crests of the craters, and steps were made in places to enable the troops to pass easily from one crater to the other, and also up to the lodgment.

20th September. The great gallery of descent being behind hand, was continued to-day, although it was Sunday.

21st September. The great gallery of descent was continued up to the back of the counterscarp wall, which was breached by a 12-pr. rifled gun,

firing live shell down the great gallery; the wall was 5 feet thick, and was penetrated by the sixth shell. (Some similar experiments in breaching counterscarp walls had been tried at Neisse, in 1865; see report of a professional tour of officers of Royal Artillery in 1865). The intention had been to sap across the ditch, but this was abandoned, as the roofing of the great gallery had been damaged by one of the shells, and it would have taken more time than could be spared to make the gallery good again.

Parties were employed completing the lodgment in the craters, and forming a backward communication with the approaches, and also in constructing bomb-proof cover at the bottom of the craters, for the protection of the miners driving galleries from them. These bomb-proofs were of different constructions, and of triangular and rectangular forms, in order that the best description might be ascertained.

22nd September. The garrison threw shells (blowing charges only) from mortars into these craters, and also rockets (with full bursting charges), but failed to drop any upon the bomb-proofs, and, therefore, no definite conclusion could be arrived at. It had been intended that an assault by escalade should take place, but this was abandoned together with the sapping across the ditch. Some troops were, however, sent forward against the block house on the right, a portion of the ground in front of which had been covered by a wire entanglement; the space occupied by the entanglement was about 50 paces square, and had not been cleared of the brushwood growing on it, which was about 3 feet high in places. The entanglement consisted of a layer of wire interlaced and secured to posts, stumps, etc., at the height of 3 feet from the ground; and of a lower layer similarly interlaced, and secured at about 1½ or 2 feet from the ground.

The mode of attack adopted, was sending forward skirmishers, who crept along on the ground, underneath the lower layer of wire, and when near enough, opened fire on the defenders, under cover of which the pioniers advanced, provided with sledges, axes, bill-hooks, etc.; they cut down the wire entanglement in four minutes, when the assaulting column moved up.

This was the last operation in connection with the siege of Fort Alexander.

APPENDIX A.

Notes on Prussian Army Organization.

The Piussian Army consists of twelve Army Corps, viz., one of the guard, and one for each of the eleven provinces; the provinces are:—1, Preussen; 2, Pommern; 3, Brandenburg; 4, Sachsen; 5, Posen; 6, Schlesien: 7, Westfalen; 8, Rhein Provinz; 9, Schleswig-Holstein; 10, Hannover; and 11, Hessen. Each army-corps is called by its number as given above. The Saxon army-corps is the 12th of the North German Confederation Army.

Each army-corps in war consists of 2 infantry divisions, 1 cavalry division, 1 brigade of artillery, 1 battalion of rifles, 1 battalion of pioniers, and 1 battalion of train.

Each infantry division consists of 2 infantry brigades (or 4 infantry regiments, or 12 battalions), 1 cavalry regiment, and 4 batteries of artillery, viz., two 6-pdrs. and two 4-prs. Total, about 14,000 men.

The cavalry division consists of two brigades (or 4 regiments or 16 squadrons), and one battery of horse artillery. Total, about 3,300 men.

The brigade of artillery of an army corps comprises the garrison artillery left in the fortresses, and the men with the ammunition train, etc.; in addition to the artillery with the infantry and cavalry divisions, there is an artillery reserve with each army corps in the field of six batteries, viz., two 6-pdrs., two 4-pdrs, and two horse artillery. Total, about 4,000 men.

The battalion of rifles is about the same strength as a battalion of infantry.

The battalion of pioniers numbers about 680 men.

Composition of an Army Corps in the Field.	Battalions		Squadrons.	Batteries.			Remarks.
	Pionier.	Infantry.		6-Pdr.	4-Pdr.	Horse.	
1st Infantry Division	—	12	4	2	2	—	And also a Train with ammunition, pontoons, field hospital, provisions, &c.
2nd " "	—	12	4	2	2	—	
The Cavalry "	—	—	16	—	—	1	
The Reserve Artillery	—	—	—	2	2	2	Total strength of Army Corps in the field, 40,000 men.
The Battalion of Rifles	—	1	—	—	—	—	
The Battalion of Pioniers ...	1	—	—	—	—	—	
Total	1	25	24	6	6	3	

The staff, (combatants only), for the above army-corps of 40,000 men consists of—

	Generals.	Staff Officers.	Adjutants.	Capts. of Engineers.	Staff Guards. Officers.	Staff Guards. Infantry.	Staff Guards. Cavalry.
Staff of the Army Corps	1	3	6	1	1	28	18
„ of Three Divisions	3	3	6	—	—	24	12
„ of Six Brigades......... ..	6	—	6	—	—	—	12
	10	6	18	1	1	52	42

During peace a regiment of infantry consists of 3 battalions; in war time a fourth is formed for a depôt, but only three take the field. Each battalion contains 4 companies; a company in peace time has 4 officers and 128 non-commissioned officers and men (combatants), and in war time 5 officers and 250 non-commissioned officers and men.

A regiment of cavalry consists of 5 squadrons, but only 4 take the field in war, the other squadron remaining at the depôt; a squadron in peace has 5 officers, and 136 non-commissioned officers and men, and in war 5 officers and 150 non-commissioned officers and men.

The Engineer soldiers of the Prussian army are called Pioniers, and are formed into twelve battalions (officered by Engineers), that is, one for each army corps. Each Pionier battalion is distinguished by the number of the army corps to which it belongs; this number is worn on the shoulder straps and epaulets of the officers and men. Each Pionier battalion is commanded by a field officer, who has an adjutant (a lieutenant). The battalion always remains at the same station, which is usually the head quarters of the army corps, unless that is not in a fortified place, when the battalion is quartered in some adjacent fortress. Neither the engineer officers doing duty with the battalion, nor the Pioniers are employed on the fortification works, but the reason why the battalions are quartered in fortresses appears to be that, on war breaking out, the depôt may be secure, and that it may raise the detachments necessary for the defence of the place. Each Pionier battalion consists of four companies, and in peace each company comprises

1 captain, 3 lieutenants (usually only one first and one second).	} 4 officers.
1 serjeant-major (long sword and officer's sword knot). 1 ensign (short sword and officer's sword knot) 4 serjeants (two first class and two second) 11 under officers (five first class, four second, and two third).	} 17 under officers.

3 buglers. 1 hospital attendant. 100 men.	nine of these one hundred and four men are lance corporals, and receive eighteen pence per month extra pay.	104 men.

Total strength of the battalion, 18 engineer officers, 69 under officers (including 1 bugle-major) and 417 men (including a clerk). In addition to the above, there are 2 medical officers, 1 paymaster, 1 armourer, and 16 tailors and shoemakers, non-combatants.

The whole of the Pioniers are not instructed in all engineer duties, but No. 1 company is the pontonier company, No. 2 and 3 are sappeur companies, and No. 4 is the mineur company. No. 1 company is composed chiefly of men who have been employed on the rivers, and they are specially instructed in making bridges; their drill is contained in the "Königlich Preussisches Pontonir-Exercir-und Dienst-Reglement," three parts; the last edition being published in two volumes by Bath, of Berlin, in 1865. The men of the other companies have, however, to assist the pontoniers, and are drilled to bring up the baulks, planks, &c. No. 2 and 3 companies are composed chiefly of artificers, and are specially instructed in sapping, according to the "Koniglich Preussisches Sappeur-Exercir-und Dienst-Reglement," (the second appendix to which is dated 1868) also published by Bath, at Berlin. No. 4 company is composed chiefly of miners, and they are specially instructed, according to the "Königlich Preussisches Mineur-Exercir-und Dienst-Reglement," in two parts, the second of which is dated 1867, also published by Bath, of Berlin. The whole of the Pioniers are instructed in making gabions, fascines, &c; tracing and superintending working parties, throwing up parallels, &c. The Engineers are also able to obtain assistance from the infantry, as there are some Infantry Pioniers in each battalion, who are put through a course of Pionier work. The "Infanterie-Pionir-Dienst," by Captain von Struensee, Royal Prussian Engineers, gives the course contemplated, but is not, I believe, an official book.

Throwing up siege batteries in the Prussian army is not done by the Engineers, but by the Artillery; the only book on the subject I could find is called "Entwurf zur Anleitung über den Bau von Angriffs-und Kusten-batterien," published at Berlin, in 1865.

When an Army Corps is made mobile, the commander of the Pionier battalion with his adjutant, takes up his quarters at the head-quarters of the army corps, where he is joined by the additional captain of Engineers, (mentioned before as part of the staff of the general commanding the army corps).

Only three of the companies take the field, viz., the 1st (pontonier), the 4th (mineur), and either the 2nd or the 3rd (sappeur) company. The other sappeur company remains at the depôt to train recruits, to form detachments for the fortresses, etc. Each of the three companies that take the field is increased, however, to 20 non-commissioned officers and 180 men; in each of the companies there are 15 men who have been trained to the special duties of each of the other companies, that is No. 1 company has 15 sappeurs and 15 mineurs put into it; No. 4 has 15 pontoniers and 15 sappeurs put to it; and the sappeur company is treated similarly.

I believe that there is also a detachment of 2 engineer subalterns, and 63 pioniers, sent with the heavy bridge train, which is under charge of a captain of the train, who has 2 train officers, 160 drivers, and 270 horses for its transport.

When several army corps are formed into an army in the field, a general of engineers, with 2 adjutants (1 captain and 1 lieutenant), and 1 captain are attached to the commander-in-chief of the army.

Captain Webber, R.E., in his "Notes on the Campaign in Bohemia, in 1866," Vol. XVI., of Corps Papers, has given a great deal of interesting information about the Engineers of the Prussian army; I observe that he mentions that there were 18 foremen of trades in each company of pioniers; I made particular enquiry on this point, and was informed that there were no such foremen now.

The following remarks relative to the corps of Piussian Engineers may be interesting:—

At the head of the Engineers of Prussia is Lieut. General von Kameke, who is styled His Excellency, as he, from his position, ranks as a general of an army corps; he is chief of the engineer corps, and of the pioniers, and is inspector general of fortifications; he has the following staff, all officers of Engineers; 1 lieut. colonel or colonel, as chief of his staff, and 3 adjutants (1 major and 2 captains).

The kingdom is divided into 4 "engineer inspections;" the engineer inspectors are usually generals, but one of the four is at present a colonel; they reside at Berlin, and have each two assistants (usually 1 captain and 1 subaltern).

Each engineer inspection consists of two fortification inspections, and one pionier inspection; the officers at the head of each of these inspections being colonels.

Each engineer inspection has from 3 to 7 fortresses in it, and each pionier inspection has the inspection of 3 battalions of pioniers.

The first "ingenieur-inspektion" comprises the 1st and 2nd festungs-inspektions, head quarters at Königsberg and Berlin respectively; and the 1st pionier-inspektion (head quarters Berlin), consisting of the guard battalion quartered at Berlin, and the 1st and 2nd battalions quartered at Dantzig and Stettin respectively.

The second engineer inspection comprises the 3rd and 4th fortification inspections, at Neisse and Berlin, and the 2nd pionier inspection (head-quarters Glogau) of the 3rd battalion at Torgau, the 5th at Glogau, and the 6th at Neisse.

The third engineer inspection comprises the 5th and 6th fortification inspections at Coblenz and Münster respectively, and the 3rd pionier inspection (head quarters at Coblenz), of the 7th, 8th and 11th battalions at Cöln, Coblenz, and Mainz respectively.

The fourth engineer inspection comprises the 7th and 8th fortification inspections, at Magdeburg and Schleswig respectively, and the 4th pionier inspection (Magdeburg), of the 4th, 9th, and 10th battalions at Magdeburg, Rendsburg, and Minden, respectively.

The pionier inspections and the fortification inspections are entirely distinct,

and the inspectors cannot interfere with each other's departments, although they may be quartered in the same town.

At each fortress there is an Engineer of the place (platz-ingenieur) with such other officers under him as may be necessary; the Engineer of the place makes the project and estimates for any works or additions to existing works (including batteries in fortresses), and forwards them to his fortification inspector, by whom they are transmitted to the engineer inspector at Berlin.

Grand questions are referred to an engineer committee that assembles at Berlin, when required, under the presidency of the inspector-general, and consists of the four engineer inspectors, the inspector of the fourth (or Berlin) fortification inspection, and two staff officers specially appointed—total, 7 members; the (8) assistants of the several engineer inspectors are allowed to be present at the meetings, but they have not any vote.

The inspector-general is required to inspect each battalion of pioniers annually, and each fortress once in two years.

W. O. L.

APPENDIX B.

Disposition of the Covering Party and Guard of the Trenches during a Siege.

The positions to be occupied by the troops, detailed for the duties of covering party and guard of the trenches, have recently been laid down by the Prussians; these troops are usually formed in four lines, which are best defined by our words sentries, piquets, supports, and main body. When attacked by sorties, the sentries slowly retire on their piquets, and, when sufficiently near to them, they open out to allow the piquets to fire; the supports at once move up, but the main body does not advance, unless the sortie is too powerful to be driven back without its aid.

The following are the general rules laid down, although, of course, they are departed from occasionally, and as much advantage as possible is taken of cover and irregularities of the ground. To enable the plates to be understood, it must be remembered that a battalion of infantry consists of four companies of 250 non-commissioned officers and men each; that each company is (when in the two deep formation) composed of three sub-divisions; and that each sub-division is divided into four sections. Plate III shows the disposition of the troops during the investment. By day (fig. 1) a few double sentries are posted about a thousand paces from the place; the piquets are about two hundred paces more to the rear; the supports are about three hundred paces further off; and the main bodies are about two thousand paces from the place. A battalion detailed for this duty keeps two complete companies as main body, and detaches one company to the right front, and one to the left as supports; each of these companies sends out—two sections to the right front, and two to the left front as piquets; and from these piquets the number of sentries.

necessary to observe the whole front is posted: according to the Prussian plan, one battalion thus posted covers about a mile of frontage.

By night (fig. 2) the number of double sentries is increased, and they are moved forward to within about four hundred paces of the place, where cover is provided for them in rifle pits, made by parties of sappers, who are sent out as soon as the sentries are posted: these rifle pits, if possible, are made where the second parallel will come. The distance between the piquets and the sentries is reduced to one hundred paces; the supports are advanced to within about 200 paces of the piquets, and the main bodies are moved up to within about 1100 or 1200 paces from the fortress.

Plate IV shews the disposition of the troops during the construction of the first parallel. On the night of breaking ground (Fig. 4) the number of troops is greatly increased; the piquets consist of whole companies, about 500 paces from the place, and 250 paces apart; from these piquets double sentries are extended along the whole front, at a distance of about 100 paces in front of the piquets; the supports for each two companies consist of the other two companies of their battalion, which are posted about 150 paces in rear of the piquets; these distances will, of course, depend upon the position of the parallel to be thrown up, as the supports should be about 150 paces in advance of the working parties. About four battalions would be required to cover the extent usually occupied by a parallel, (say $1\frac{1}{4}$ miles), and in addition there should be strong main bodies posted on both flanks, at about 1500 paces from the place; these main bodies may have artillery and cavalry attached to them.

At day-break the covering party retires, and occupies the position shewn in Fig. 5; where the sentries are about 200 paces in rear of the parallel, the piquets 200 paces more to the rear, and the supports 300 paces further still; the main body being kept about 2000 paces from the place. In the Prussian plan no notice is taken of the guards of the trenches, but the letter-press states that they are to be provided from the covering party, although the strength of the guards of the trenches is to depend upon the strength of the garrison, the nature of the ground in front, and the length of the parallel; it is said that there should be one man to every 2 or 3 paces length of parallel. Until the parallel is sufficiently widened out, to allow of the guards of the trenches remaining in it, they are posted about 50 paces in rear, advantage being taken of any undulations there may be; and, if the ground affords no cover, the sub-divisions lie down (with sub-division intervals between them) with their arms in their hands; each sub-division posts one sentry on the berm.

Plate V shews the disposition of the troops after the completion of the first parallel. By day (Fig. 6) six companies (two per battalion) are posted in the parallel; these companies post a few double sentries in the rifle-pits, that have been made about 400 paces in advance; these men remain in the rifle-pits all day, and keep down the artillery fire of the place as much as possible. The other two companies of the battalions are placed as supports in the communications about 800 paces in rear of the parallel; and the main bodies (with artillery and cavalry if necessary) are kept from 800 to 1000 paces further to the rear.

At dusk (Fig. 7) each company in the parallel sends out a sub-division, about 300 paces in advance, and these piquets furnish double sentries, about 100 paces further to the front. The half battalions in support move up to within about 300 paces of the parallel, and the main bodies likewise advance to within about 1000 paces of the parallel.

Plate VI shews the disposition of the covering party during the construction of the second parallel. During the night on which the second parallel is commenced, (Fig. 8), the arrangement is very similar to that adopted on the night of the opening of the first parallel; the distances are as follows: the companies on piquet are about 75 paces in front of the working parties, and the line of double sentries in rifle-pits, about 75 paces more in advance; the supports are kept about 75 paces in rear of the working parties, and the main bodies are posted in the first parallel.

At day break (Fig. 9) the troops are retired, the main body to about 2000 paces from the place, the supports into the first parallel; the companies or piquets retire behind the second parallel, leaving some double sentries in the rifle-pits. (For rifle-pit, see Plate III, Fig. 3).

When the advance is being pushed by the regular sap, the sap-heads are protected by a few (say four) rifle-pits, dug during the night, about 30 paces from the sap-head; the piquets remain in the parallel immediately behind the rifle-pits, or in the returns of the approaches.—See Plate VI, Figs. 10 and 11.

When the third parallel is completed, it is occupied by the piquets; the supports move up into the second parallel, and the main body occupies the first.

APPENDIX C.

Formation of Working Columns for Parallels, Communications, etc.

Infantry detailed for working parties parade in forage caps and undress, without any belts; they carry their rifles with bayonets upwards, slung across their backs, with the sling on the left shoulder; they take their haversacks, and a packet of cartridges in them.

The infantry working parties are formed in columns of sub-divisions, 2 deep, at quarter distance; the number and strength of these columns depending on the extent of parallel, etc., to be executed.

The sub-divisions are drawn up in double column, if they are to be extended from the centre to both flanks, and in single column if to one flank.

If the extension is to be to the right, the formation is left in front; if to the left, then right in front. No single column consists of more than 2 companies (or 6 sub-divisions), and no double column of more than 4 companies.

Each column has a working reserve of about 10 or 15 per cent. of its strength, which falls in immediately in its rear.

The following Engineers are told off for general superintendence :—

For 1200 paces of parallel or less, 1 captain.

For above 1200 paces of parallel, 2 captains.

For each communication, 1 captain.

To each company of infantry, 1 lieutenant, 3 non-commissioned officers (*i.e.*, 1 for each sub division), and 12 pioniers (*i.e.*, 1 for each section).

In addition each single column has 1, and each double column has 2 non-commissioned officers of pioniers, to assist the engineer officers in placing the men along the trace as the columns advance.

1 non commissioned officer and 2 pioniers are attached to the working reserve, which is also augmented by the non-commissioned officers and pioniers of the tracing party, when the tracing is completed.

The working parties parade at the engineer depôt, two hours before sun-set, and are detailed by the engineer field officer of the day.

The working party is drawn up in the following order. In the first line the columns for the parallel, with their working reserve; in a second line, 50 paces in rear of the front line, the companies (in column of sub-divisions) arranged in the order they will eventually have in the trenches; in rear of each company is its working reserve; in a third line are placed the parties to execute the returns of the zigzags.

The position of the engineer officers, &c., is as follows :—

Captain of Engineers, in front of the column to be extended.

1 Lieutenant of Engineers, on the pivot flank of the infantry officer commanding the company.

The 3 non-commissioned officers of pioniers, covering the commanders of the three sub-divisions.

The 12 pioniers, 1 in rear of each section, in the supernumerary rank.

The additional non-commissioned officer of pioniers, told off to assist to place the men on the trace, covers the engineer officer on the flank of the leading company. For the working reserve the non-commissioned officer of pioniers covers the infantry officer commanding the party, and the pioniers fall in in the supernumerary rank.

For the returns at the end of each communication, special parties are detailed of 1 non-commissioned officer of pioniers and 12 infantry, who parade in rear of the working reserves of the column for the communications.

Distribution of Tools at the Depôt.

The Engineer in charge of the depôt, having received from the engineer field officer of the day the numbers of each separate working column, arranges the requisite tools. A spade is provided for every man, and a pick for every two, three, or four men, according to the nature of the soil. The tools are arranged by companies, and placed on the pivot flank, for a single column, and in the centre, for a double column. The tools are in piles, the spades being about three paces from the column, and the picks three paces from the spades; they are distributed to the working party by the non-commissioned officers and pioniers attached to it.

The working party carry their arms, with bayonets fixed, slung across their

backs, with the sling on the left shoulder. The spades are carried with the blades under the right arm, and the handles turned down. The picks are carried with the iron over the left fore-arm, which is bent at right angles (N.B. position somewhat similar to the support in the manual exercise). Spare tools, amounting to 20 per cent of the total tools given out, are, at the same time, issued to the working reserve. The non-commissioned officers of pioniers carry 4 feet measuring rods.

General Instructions for Working Parties. As soon as the tools have been distributed, the men are instructed as to the work they have to do, and cautioned as follows:—

1st, That all noise is to be avoided, especially clanking the tools and rifles together.

2nd, That no orders are to be given louder than is absolutely necessary.

3rd, That talking, smoking, and striking a light are strictly forbidden.

4th, That, although step need not be kept, each man is to keep up with the man in front of him, without getting too close.

5th, That each workman must excavate the trench allotted to him, and not leave the work under any circumstances.

6th, That if the retreat of the working party is ordered, on account of a sortie, they must take their tools with them, and keep them until ordered to lay them down.

APPENDIX D.

Tracing of First Parallel and Communications, and Extending Working Parties.

A tracing party is attached to each working column, and consists of one engineer officer, one non-commissioned officer of pioniers, 3 pioniers, besides as many pioniers as may be necessary for workers, and for carrying the tracing materials. These materials are,

Several reels of ½ or ¾ inch white tape, which must be 5 per cent longer than the line to be traced.

Pickets 18 inches long, 3 pickets for every 10 ruthen, 120 feet.

2 light mallets, with their heads covered with felt, to prevent noise in driving the pickets.

3 bags for carrying pickets; these bags are carried with a strap over the men's shoulders.

The engineer officer, in charge of the tracing, having previously fixed upon some objects as points of direction, goes forward at dusk, with a few pioniers, and places one at each point where there is to be a change of direction. These men are left as markers, and the officer returns to the starting point, where the end of the tape is made fast to a picket. He then marches slowly along the line of direction of the trench, closely followed by 2 pioniers, carrying a reel of tape, which is payed out as they go. The non-commissioned officer and other

pioniers follow and drive in the pickets at every 20 or 25 paces, taking a turn with the tape once round them. The men carrying the materials follow the men who are unreeling the tape.

As soon as the officers have traced their respective portions of the parallels or communications, they return as quickly as possible, and report to the senior engineer officer of the column the completion of the tracing. After this, the tracing officer reports himself to the engineer field officer of the day, and the tracing party join the working reserve of their column.

At each point of the parallel to which the working columns will be directed, and from which the deployments on the trace are to be made, 2 pioniers are placed 10 paces in rear of the trace, and 10 paces from one another, in order to mark the points at which the heads of the columns will have to wheel.

Between these points and the rendezvous of the columns, a few men are placed to prevent the columns losing their way in the dark.

On approaching the proposed line, the columns will turn inwards, and march in file on the markers (i. e., right or left turn; left or right wheel). The leading files march straight on to the tape and halt; the rear rank, 2 paces from the front rank men.

The remaining files on reaching the markers, wheel to the left or right, and then right or left form in single rank on the tape; the men being, in each case, 2 paces apart.

In order to insure this being done correctly, as soon as the first 2 men are placed, the engineer officer marches along the tape, and halts at every 2 paces, when the non-commissioned officer of pioniers with him seizes the proper man and places him.

Each sub-division begins work as soon as the tail of the column has passed it. Each man then places his rifle on the ground, 5 paces to his rear, with the butt nearest to him, and his haversack close to it: and commences work 1 spade's length behind the tape, which is the front cutting line. The trench made on the first night is 4 feet deep and 3 feet wide at the bottom: the front slope always has a base of 1½ feet, while the reverse is left as steep as it will stand: if the reverse can be left perpendicular, the trench will be 4½ feet wide at the ground line. The working reserve of each company, with the spare tools, is formed up 50 paces in rear of the centre sub-division.

The returns are made by the special parties of 1 non-commissioned officer of pioniers, and 12 infantry detailed for each: each return is 20 yards long, the last 8 yards being curved towards the rear: the returns have the same section as the parallel.

APPENDIX E.

Notes on the Construction of Prussian Siege Batteries.

Definitions of Batteries.

The terms elevated and sunken batteries have not quite the same meaning in the Prussian service as in ours. For instance, the term elevated (erhöhete) battery is applied to any battery in which the gun platform is raised above the ground level. Horizontal (horizont) battery, when the gun platforms are on the level of the original ground. Sunken (versenkte) battery, when the gun platform is sunk below the ground level.

Normal Dimensions.

The normal dimensions of a sunken battery are as follows: the interior of the battery is sunk 3 feet 6 inches, and the crest is raised 3 feet 6 inches, making a total height of parapet 7 feet: thickness of parapet, 21 feet. Minimum distance of the guns apart, 16 feet, plus the width of the neck of the embrasure: the necks of the embrasures are made 2 feet 6 inches wide for rifled guns, and 3 feet for howitzers or shell guns: the width of the embrasure at the exterior crest line is 8 feet, exclusive of the slopes of the cheeks. Width of each traverse is 6 feet at top. (See Plates VII and VIII).

Accessories.

The following accessories are required for each battery : viz., 1st, a magazine, generally in the epaulment or extreme half merlon. 2nd, a splinter-proof to cover the men filling shells. And 3rd, a shell recess for every two guns for filled shells. It is laid down as a rule that the battery should be so far completed in one night, that the guns can be mounted, and fire opened next morning. With this object, therefore, the excavations are first completed at the platforms, to enable them to be laid and the guns mounted, while the rest of the battery is being thrown up. Should the magazine not be completed by the morning, the guns open fire, being supplied from portable magazines. There appears to be no rule laid down to define the proportions of traverses to the number of guns. In a battery thrown up at the Coblenz siege operations, there were 4 guns without any traverses between them. At the side of each platform, a couple of small trestles made of pickets, bound together with wire, are fixed as a stand on which to rest the sponges and rammers.

Tracing.

The first line traced is the magistral line of the battery; a line representing the centres of the ground fascines of the interior slope. The next line traced is the rear line of the bottom of the interior excavation. The third line traced is the inner edge of the berm (3 ft. wide) which is allowed to remain untouched until the battery is nearly completed. The fourth line is the exterior crest. These lines are measured by 6 ft. rods, and are marked on the ground by a slight line cut with a pickaxe. Pickets, about 3 ft. long, are

driven in at all the angles of the battery, and in the prolongation of these lines. No tracing tapes nor tracing lines are used. The lines of fire of the embrasures are next picketed out and pickets are driven at the points which show the width at the sole of the embrasures.

Working Party. The following is the working party for a sunken battery for two guns:

Fascine men	9 per merlon*	....	Total 27	men.
Diggers	20 „	....	„ 60	„
Assistants bringing up materials	10 „	....	„ 30	„
Superintending, 2 per merlon*	6 N.C.O.			
Ditto at the Depôt (see Fig. 20)	1 „			
Ditto bringing up materials	2 „			
Total for 2 guns	9 „		117	„

Magazine.

Working party	1 „	....	20	„
Bringing up materials	1 „	....	10	„
Shell recess	1 „	....	8	„
Shell filling room	1 „	....	20	„
Bringing up materials	2 „	....	30	„
Total for a sunken battery for two guns with the requisite accessories	15 N.C.O.	....	205	men.

Construction of the Battery.

1st. An excavation is made 12 ins. wide, viz.:—6 ins. on either side of the magistral line of the battery, for the whole length of the gun portions, and at the sides and ends of the traverses. In this trench the ground fascine is placed by the fascine party, care being taken that it is half buried, and that it is level. The fascine is then picketed down with several stout pickets (about 1½in. in diameter, and 3 ft. long) which are driven home.

2nd. As soon as the ground fascines are laid, the diggers bring up the gabions and set them, with the assistance of the fascine party. The gabions for battery construction are somewhat larger than those used in the saps, and the pickets are several inches longer than the gabions themselves, in order to allow of their being driven into the ground fascines, etc.

As the gabions are not quite regular in dimensions, those at the throats of the embrasures are set first, and then the intermediate ones are placed close to one another, the inner pickets of each gabion on the centre of the ground fascine, and the outer pickets on the ground. By this means the gabions have a slope to the front of about $\frac{1}{4}$. When the whole of the gabions have been placed, and their position found correct by the superintending officers, the pickets are driven home.

* The extreme portions right and left of the guns are calculated as merlons and not as half merlons.

For placing the gabions, 2 men per gabion are employed, viz.: 1 of the fascine party standing in front, and 1 digger standing in the interior of the battery. As soon as the gabions are all picketed down the excavation begins. The diggers are placed in three rows (see Fig. 19,) the 1st row as close to the 3 ft. berm as possible, who throw the earth directly into and beyond the gabions. The other rows shovel the earth on to the berm, if unable to throw it on to the parapet. As many of the fascine party as may be necessary are employed in ramming the earth in the parapet in layers. This is particularly necessary under the soles of the embrasures, and under the anchor fascines. The rest of the fascine party are, at the discretion of the officer in charge, placed either on the berm to shovel forward the earth thrown there by the rear rows of diggers, or excavate the ditches on the flanks of the battery to form the epaulments.

As soon as the earth in the parapet is about 1 ft. 6 ins. high, and has been well rammed, the anchor fascines are laid, having been previously attached by wire fastenings to each of the gabions. These anchor fascines are 14 ft. long for ordinary merlons, and 16 ft. for flank merlons. The centre of the anchor fascine is laid about 3 ft. from the gabions (see Figs. 21 and 22.)

Embrasures.

When the parapet has been raised as high as the top of the ground fascine, and has been well rammed, a short fascine, 2½ ft. long, is laid at the neck of the embrasure and picketed down to the ground fascine, by which means the height for the sill of the embrasure is obtained. In addition to these fascines, a hurdle, 9 ft. long, is laid against the genouilliere and picketed into the parapet by 9 horizontal pickets. The cheeks of the embrasures are revetted, sometimes with gabions and sometimes with hurdles, which are picketed into 2 ground fascines, buried on either side of the sole of the embrasure. These hurdles are kept in their places by anchor fascines or pickets and the usual wire connection.

Platforms.

There appear to be three descriptions of siege platforms in use.

1st. The platform for guns on light field carriages consisting of two planks, 18 ft. long, placed together in the centre for the trail to recoil on; and one plank on either side for each wheel. These planks are not fastened together, but merely picketed in their places at the required distances.

2nd. The platform for the little 7-pounder Coehorn mortars, which is simply a stout plank 9 ft. long and 12 ins. wide, is laid on three cross sleepers which are sunk in the ground.

3rd. The ordinary gun or mortar platform, the former 18 ft. long,* and the latter 14 ft. long, both 9 ft. wide. (See Fig. 12.)

The ordinary gun platform is laid as follows: 5 sleepers are laid at the required depth in the centre of the platform, the centre sleeper being in the line of fire, and the others touching it on either side. The remaining two sleepers are laid with their centres 3 ft. 6 ins. from, and parallel to, the line of fire. At the rear of the platform a baulk is laid at right angles to the above mentioned sleepers, against which their ends abut; seven stout pickets are driven into the ground in rear of this baulk. The planks are laid across the sleepers, but with

* In Fig. 12, the gun platform has been accidentally drawn and figured only 14 ft. long.

their ends projecting a foot alternately to the right and left. Behind each projecting end two pickets are driven. The front and rear planks are nailed down to each sleeper; the other planks are secured by three nails each.

To check the recoil of the guns mounted on travelling carriages, two wedges are placed behind the wheels; they are 6 feet long, 12 inches high, and 6 inches broad; the points being shod with iron. It appeared to be the opinion of the Prussian Artillery officers, that these wedges answered very well, but we had no opportunity of observing their effects.

Field Powder Magazines. (See Pl. VII, Figs. 12 and 13.)

The sides of the magazine are formed of gabions, with fascines above them. The roof is of fascines, splinter-proof timbers, and earth. The floor is covered with hurdles. The normal dimensions of the magazine appear to be 6 feet long, by 4 or 6 feet wide, and 5 feet high. Thickness of parapet, from exterior crest to the centre of the gabions revetting the magazine, 8 feet.

Thickness of roof—One layer of splinter-proof timbers, 6 inches.
One layer of fascines .... 9 inches.
Three or 4 feet of earth, say 3 feet 6 inches.
Total vertical cover ...4 feet 9 inches.

Shell Filling Room. (See Pl. VII, Figs. 12 and 14)

This consists of a space about 12 feet long by 10 feet wide, having the parapet on one side, and on the other, a row of gabions, filled with and backed up by earth. The roof is sloping, and is formed simply of one row of timbers, or iron rails, one end of which rests on the parapet, and the other on the row of gabions at the back. On the top of the gabions, a longitudinal sleeper is picketed, as a bearer for these baulks.

Shell Recess. (See Pl. VII, Figs. 12, 15 and 16.)

These recesses are 6 feet long, 30 inches or 1 gabion high, and 2 gabions deep. The cover consisting of two rows of timber, and about 2 feet of earth.

Musket-proof Shutter for Embrasures. (See Pl. VIII, Fig. 18.)

This shutter consists of two flaps, each 2 feet 3 inches high, by 1 foot 9 inches wide; these flaps might be made of oak, iron, or steel. Each flap is secured to an upright plank, the lower end of which rests on a sill placed on the ground in front of the platform: these uprights keep the flaps at the right height from the ground, for masking the embrasures. When the gun is ready to be run up, the flaps are moved right and left, which is easily managed, as they pivot on the feet of the uprights. The flaps move in a plane parallel to the interior slope of the parapet; and, in order that the unevenness of the gabions may not interfere with this motion, a riband of wood is fastened against the interior slope, a few inches below the sill of the embrasure. The pickets which keep this riband up also prevent the flaps from opening out further than is necessary for the working of the gun.

APPENDIX F.

Notes on the Several Kinds of Saps in use in the Prussian Service.

Flying Sap. For flying sap, the working parties are formed up as previously described in Appendix C. The gabions are laid out two deep at the depôt, in lines corresponding to the number of men in the sub-divisions. Each man carries a gabion in his right hand, and a pick or shovel in the left. They march on to the trace, and form up in single rank as usual, each man placing his gabion in front of him: the placing of these gabions is done under the superintendence of an engineer officer, and non-commissioned officer of pioniers. The tools are then laid against the gabions, and the men unsling their arms. The front rank then retires 10 paces, and, after being formed as a company, is marched to the rear, where the men remain ready to replace casualties, or to bring up more gabions if required. By this arrangement, each man in the rear rank is left with 2 gabions in front of him, and a pick and shovel to work with, although he only brought up one of each. The front rank of each company does not retire until the tail of the column has passed clear of it, and the rear rank does not begin work until after the front rank has retired. The working reserve of each column brings up as many gabions and tools as there are men in it. The section of the first night's work with flying sap, is given in Pl. IX, figs. 27 and 28. It is the same as that for the first parallel, with the exception of having a gabion revetment.

Single Sap. For single sap, the brigade consists of 1 non-commissioned officer, 6 sappeurs, and 2 pioniers. The sappeurs are numbered from 1 to 6. Nos. 1, 2, 3, and 4 are actually digging, and Nos. 5 and 6, in rear, filling sand bags, &c. The numbers change rounds as soon as the leading sappeur has filled 5 gabions in easy soil, and 3 in difficult soil. No. 6 then becomes No. 1; No. 1 becomes No. 2, and so on. The two leading men in the sap kneel. The dimensions of the portions of work done by each number are shown in Pl. IX, figs. 23, 24 and 25. As soon as a gabion is placed, 5 sand bags are piled against it by No. 1, before he begins to fill it. Nos. 5 and 6 crown the parapet with 3 fascines, which are hammered on to the pickets of the gabions with a special maul, Pl. X, fig. 31. The general working of the sap, and mode of advancing the sap roller, are nearly the same as in our regulations, except that the construction and position of the sap roller are slightly different, and that the sand bags they use are smaller and lighter than ours. The sap roller is 8 feet 8 inches long, and 3½ feet in diameter; it is composed of only one cylinder, which is entirely filled with stout pickets. The ends of the roller are closed by pieces of wood,

which are kept in their places by bands of hoop iron passing round each of the pickets of the sap roller: see Pl. X, fig. 33. The sap roller is placed with its centre in the line of the crest of the parapet, so as to protect the gabions at the head of the sap as much as possible. For placing the gabions, a short sap fork is used, to the handle of which a small iron prop is attached, about 12 inches from the fork: see Pl. X, fig. 32. The Prussian rate of progress of this sap is said to be about 3 gabions, or 5 feet 3 inches per hour in stiff soil. The Prussians do not appear to consider that this single sap is practicable for working in daylight, under fire from rifled arms.

Turkish Sap. The Turkish sap (erdwalze) is the one which the Prussians seem to consider the best for working in daylight: see Pl. IX, fig. 26. No sap roller is used, but an unrevetted earthen parapet, at the head of the sap, answers the purpose. This parapet is continually being shovelled forward, as the sap advances. The number of men required is 1 non-commissioned officer and 15 sappeurs: they are formed in three ranks, and numbered off: the three Nos. 1 work abreast, at the sap head, and, together, make a trench 3 feet deep, 7 feet wide at the top, and 5 feet at the bottom. They throw their earth to the pivot flank and to the front; and they also shovel forward the parapet at the head of the sap. The three Nos. 2 work abreast, 6 feet in rear of the Nos. 1: they increase the size of the trench to 3 feet 6 inches deep, $8\frac{1}{2}$ feet wide at top, and 6 feet at bottom. The three Nos. 3 work abreast, 6 feet in rear of the Nos. 2; they deepen the trench to 4 feet, and make it 10 feet wide at top, and 7 feet at bottom; Nos. 2 and 3 throw this earth to the pivot flank; Nos. 4 and 5 rest.

As soon as the sap has advanced 1 foot, the men change rounds; Nos. 5 become Nos. 1; Nos. 1 become Nos. 2; and so on. This sap is said to advance from $2\frac{1}{2}$ to 4 feet per hour.

Double (Gabion) Sap. The double sap with gabions (see Pl. X, figs. 29 and 30) is intended for work at night; it consists of two single saps, working parallel to one another. The two sap rollers, covering the sap head are placed with their inner ends touching. To cover the spot where the 2 sap rollers meet a traverse, consisting of 120 sand bags, is placed on the ground between the saps. The brigade for this sap consists of 1 non-commissioned officer, 12 sappeurs, and 4 pioniers. The tongue of earth, between the two saps, is thrown out by a party of 1 pionier and 8 infantry, who follow the sappeurs, after 25 gabions have been placed.

Double Turkish Sap. The double Turkish sap is intended for use by day. It requires the same number of men as the single Turkish sap, and it is worked in very nearly the same way. The dimensions are slightly different, and are given in Pl. X, figs. 34 and 35, which shows the saps with traverses left.

Cube Sap. Würfel, or cube sap, is sometimes adopted when traverses are required, to protect the trench: see Pl. X, fig. 36. It is worked in much the same way as the ordinary double sap, but requires two extra brigades to sap along *a. a. a.*, and make the cube traverse after the head of the sap has advanced clear of the traverse. Anchors are used in these saps, to give greater stability to the gabions. An anchor consists of a short fascine or piece

of brushwood, which is attached, by about 2 or 3 feet of twisted wire, to a cross piece of wood inside the gabion, and is thrown over and gets buried in the earth forming the parapet; occasionally, the cross piece is put across the front of 2 gabions, when 1 anchor keeps 2 gabions up. These anchors seem very useful, particularly in saps on sloping ground, and prevent the gabions being overturned by the pressure of the earth behind. (See Pl. X, fig. 37.)

Crowning sap.

The Prussian crowning sap, Pl. XI, fig. 38, and Pl. XII, fig. 39, is used for crowning the covered way, and is much the same as our half double sap.

No. I Brigade, of 1 non-commissioned officer, 6 sappeurs, and 2 pioniers, saps along parallel to, and about 12 ft. or 14 ft. from the crest of the glacis with the ordinary single sap, the sap-head being, however, protected by 2 sap-rollers, and, if necessary, owing to the obliqueness of the reverse fire, by a sand-bag parapet.

Three other brigades under 1 non-commissioned officer, consisting of 2 sappeurs and 2 pioniers each, are required to form the necessary attached and detached traverses (brustwehr-und umgangs-traverse).

The first traverse is commenced about 36 ft. from the capital, at the point marked A (Fig. 39), and as soon as the leading sappeur of No. I Brigade has advanced seven gabions beyond it, No. 3 sappeur places three gabions (*a*, 1, and 2) on the reverse of the sap and perpendicular to it; he makes a trench in rear of them and fills them, thus forming a cover, behind which (as soon as the last of No. I Brigade has passed (*a*) No. II Brigade begins to sap, and places five more gabions in the same line for the rear of the traverse, after which this brigade changes its direction to form the end of the traverse, but not until it is covered from the fire of the place by the detached traverse made by No. III Brigade. When No. 3 sappeur of No. I Brigade has advanced to the sixteenth gabion from A, he again places and fills three gabions (*c*, 1, and 2) on the reverse of the trench; behind this parapet No. III Brigade commences to sap and make the rear of the detached traverse; this detached traverse has to be made long enough to protect from the fire of the next salient the passage round the end of the attached traverse.

No. IV Brigade forms the front of the attached traverse, which is made eight gabions thick, but it does not commence work until its starting point *b* is covered from the fire of the next salient by the parapet formed by No. III Brigade; it also works round the end of the traverse until it is completed.

No. II Brigade is moved forward and commences the rear of the next attached traverse as soon as No. I Brigade has got clear of its position; the distance between the attached traverses is 36 ft., or only 32 ft. when the space between them is to be converted into a 2-gun battery.

The trench formed by No. I Brigade through the attached traverses is filled up and the revetment made good as soon as the passage round the end of the traverse has been completed.

If the fire from the next salient takes the sap very much in reverse, a temporary traverse of gabions filled with sand bags may be necessary, as at *d*.

APPENDIX G.

Notes on Experiments with different kinds of Saps, and the Effects produced on them by Musketry and Artillery Fire.

The four following saps were started parallel to one another and only a few yards apart, so as to be in the same description of soil, with the view of testing their relative merits; the rates of progress given are the average of four days' work:—

No 1. The ordinary single (kneeling) sap, 3 ft deep, employing 8 men, advanced at the rate of 5 ft. 6 in. per hour.

No. 2. The ordinary Turkish sap, 3 ft deep, employing 15 men, advanced at the rate of 3 ft. 3 in. per hour.

No. 3. An experimental sap proposed by Colonel Leuthaus, Prussian Engineers, $4\frac{1}{2}$ ft. deep, employing 12 men, advanced at the rate of 5 ft. 6 in. per hour.

No. 4. The Austrian sap, 6 ft. deep, employing 12 men, advanced at the rate of 3 ft. 3 in. per hour.

The first two saps have been already described in Appendix F.

Col. Leuthaus' Sap.

No. 3 or Colonel Leuthaus' sap (see Pl. XII, fig. 40) was worked by a brigade of 1 non-commissioned officer and 12 sappeurs. The head of the sap is protected by a sap-roller, 8 ft. 3 in. long, and 21 in. in diameter; a few sand bags are placed behind the sap-roller and on the berm to improve the cover; the trench is $4\frac{1}{2}$ ft. deep, $1\frac{1}{2}$ ft. wide at bottom, and $2\frac{1}{2}$ ft. at top. No. 1 sappeur, as soon as he has picked down a quantity of earth, falls a little to the rear, and No. 2 immediately shovels the earth along the trench to the rear, and No. 1 recommences picking again as soon as possible. The earth is removed from the trench by Nos. 3 and 4, who use long handled shovels and throw the earth well towards the head of the sap, leaving a 2-ft. berm; the parapet is unrevetted. These four sappeurs are relieved when the sap has been advanced $1\frac{2}{3}$ ft. by four others, who in the mean time remain resting in the rear. The other four men work without any reliefs as follows:—Nos. 9 and 10, at 16ft. from the head of the sap, widen it to $2\frac{1}{2}$ ft. at bottom and $3\frac{1}{2}$ ft. at top; and Nos. 11 and 12 work 6 ft. farther to the rear, and widen the trench to $3\frac{1}{2}$ ft. at bottom and $4\frac{1}{2}$ ft. at top.

The Austrian Sap.

No. 4 or the Austrian sap (see Pl. XII, fig. 41) is worked by a brigade of 1 non-commissioned officer and 12 sappeurs. The head of the sap is protected by a wedge shaped woooden shield plated with iron

about a quarter of an inch thick; it is about 6 ft. wide and 4 ft. long, the rear end of the shield being raised about 12 in. The trench is 6 ft. deep, 1 ft. wide at bottom, and 4 ft. at top. No. 1 sappeur (as in Colonel Leuthaus' sap) only picks, and the earth is got out of his way by No. 2; it is afterwards thrown on to the parapet by Nos. 2 and 3, who also revet the parapet with small gabions, only 1½ ft. high. No. 4 works at 18 ft. from the head of the sap, and widens the trench 8 in.; Nos. 5 and 6 work respectively 6 ft. and 12 ft. in rear of No. 4, and each widen the trench 8 in., which is then 3 ft. wide at bottom and 6 ft. at top.

Before the experiments to try the effects of firing against the saps were commenced, stuffed figures to represent the sappeurs were placed in their proper positions in each sap. The firing was in all cases directed against the heads of the sap, and at an angle of from 30° to 45° with their parapets.

Musketry fire.

The first experiment was with infantry armed with the Prussian needle-gun. A section fired four rounds against each sap-head at a distance of 100 paces, but none of the dummies were hit. The second experiment was similar to the last, with the exception of the range being increased to 200 paces. The only damage done was in the Austrian sap, where one man was hit and a sap-fork was struck three times, but it appeared to be owing to the shield being badly placed.

Fire from wall-pieces.

The third experiment was from the Prussian wall-piece (described in Appendix H), at a distance of 400 paces. The only damage done was in No. 3, or Colonel Leuthaus' sap, in which No. 1 sappeur was shot through the body by a ball which passed through the sap-roller.

Artillery fire.

The fourth experiment was with artillery firing live shell at a range of about 450 yards. A rifled 12-pdr. was used against Nos. 1 and 2 saps, viz., the ordinary and the Turkish sap; a rifled 6-pdr. was fired against No. 4, or the Austrian sap; and both rifled 4-pdrs. and 6-pdrs. were used against No. 3, or Colonel Leuthaus' sap; 28 live shells were fired altogether, of which 5 missed the mark entirely, and the remaining 23 hits effected the following results:—

No. 1, or the ordinary kneeling sap, was almost entirely filled in with gabions, sand-bags, &c., after three rounds; the positions of the three leading sappeurs were completely laid open, and they were struck. Some of the gabions were hurled 20 paces to the rear of the trench. Some shells were afterwards fired at the sap-roller, and two went through without bursting in it or displacing it.

No. 2, or the Turkish sap, was also greatly damaged after three rounds, and an opening made in its parapet 2 ft. wide at the ground line and 10 ft. at the crest. Six of the sappeurs in it were wounded.

In No. 3, or Colonel Leuthaus' sap, owing to the shells having struck high, the upper half only of the parapet was destroyed. Sand-bags were driven into the trench, but none of the men were hit, and there was still a fair amount of cover in it.

No. 4, or the Austrian sap, was, after seven hits, still in a perfectly workable condition throughout, though 6 of the gabions at its head had been displaced,

and one of them and a sap-fork had been knocked into the trench. None of the men were struck, and the shield was not moved.

Musketry fire.

The fifth experiment was with infantry fire at 200 paces against the sap-heads as opened up by the artillery; the object being to see whether it would be possible for working parties to make good the saps again. Targets, the height of a man, were placed in the several saps, and 210 shots from the needle gun were fired at the four saps (about the same number against each). The number of hits was as follows:—No. 1, or ordinary kneeling sap, 20; No. 2, or Turkish sap, 24; No. 3, or Colonel Leuthaus', 1 hit; and No. 4, or the Austrian sap, none.

Hand-grenade fire.

The sixth experiment was firing hand-grenades and pound shot at the sap-heads from 50-pdr. mortars at a distance of 200 paces, wicker baskets being used to hold the projectiles. The range of the pound shot was, as a rule, rather short, but a good many of the grenades fell in the saps.

Comparison of the different saps

From the above experiment the relative advantages and disadvantages of the several saps are as follows:—

The advantages of No. 1, or the ordinary kneeling sap, are, that it requires very few men (only 8), and that it can be pushed as rapidly as any of the others; the only sap that can nearly keep up with it (No. 3, or Colonel Leuthaus') requires half as many men again. Its disadvantage is that it has very often a weak point in its parapet; viz., a gabion before it is filled.

The only advantage of No. 2, or the Turkish sap, is that it never has any one part of its parapet weaker than another. It has the decided disadvantage of going very slowly.

The great points in favour of No. 3, or Colonel Leuthaus' sap, are that it can be pushed nearly as rapidly as any other sap, while the men have better cover than in the only sap which can compete with it as regards pace. It has the disadvantage (at present) of the sap-roller at its head not being able to resist wall-pieces.

No. 4, or the Austrian sap, has the advantage of great safety for the men, even against artillery fire; but then it has the disadvantage of advancing very slowly; although in these trials its rate was only 3¼ ft. per hour, yet we understood that the Austrian sappeurs managed to push this sap much faster, viz., 5 ft. per hour. It would, of course, often be impossible to make use of this sap (6 ft. deep) on account of water or rock being met with.

APPENDIX H.

Prussian Wall-piece (Wall-büchse).

The wall-piece in use in Prussia is a breech-loader, rifled with four grooves, and fires a cast-steel projectile about $2\frac{1}{4}$ in. long by $\frac{7}{8}$ in. greatest diameter, weighing 4 oz. The length of the barrel is about 3 ft. $7\frac{3}{4}$ in.; the breech-loading arrangements are the same as those of the Prussian needle-gun. The wall-piece can be carried easily by two men, but we were unable to ascertain its weight; it is laid on the parapet and fired by one man, who places his shoulder against a padded crutch, which is fastened to a cylinder in which there is a spiral spring to diminish the effect of the recoil.

We witnessed some experiments with these wall-pieces on the 16th September. The firing was against sap-heads at a distance of 400 paces, when one shot from a wall-piece went through a sap-roller 21 in. in diameter, and into a dummy, No. 1 sappeur, behind it. On this occasion, Infantry, armed with the Prussian needle-gun, fired against the same sap-head at distances of 100 and 200 paces, but no bullet penetrated the sap-roller.

On the 21st September the wall-pieces were fired at a range of 200 yds.: 1st against a sap-roller 21 in. in diameter, when four shots went through; 2ndly, against a brushwood gabion round which three layers of 2-in. rope had been coiled, when two shots went through; 3rdly, against a wall 3 ft. thick at top and 4 ft. at base, made of sand-bags filled with earth, when none of the shot appeared to penetrate more than 2 ft. into the wall; none went through. Several of the shot broke in two.

APPENDIX I.

Notes on Prussian Mining.

The size of the Prussian common gallery is 3 ft. high by 2 ft. wide in the clear; the only peculiarities about the cases in use are that one of the stanchions has not got a tenon at the lower end, and that the ground-sill on the same side has a deeper mortice. The ground-sill is first placed, then the stanchion with the two tenons, and then the cap-sill; finally, the tenon of the other stanchion is put into the mortice of the cap-sill, and its lower end pushed

out till the stanchion is vertical, and then a key or wedge is driven into the deep mortice of the ground-sill, which prevents the stanchion being forced inwards by earth pressing against it. The advantage of this description of case is that additional earth need not be cut away overhead to allow of one end of the cap-sill being raised, as it has to be when there is a tenon at the bottom of the stanchion to get into place. The wheels of the mining trucks are prevented from coming in contact with the wedges or keys by means of fenders with curved ends fastened on to the sides of the trucks. The Prussians put the wedges alternately on the right and left sides of the gallery.* The Prussians make their cases of slighter materials than we do; they use, apparently, $1\frac{1}{4}$ in. or $1\frac{1}{2}$ in. stuff instead of 2 in. They likewise use the same cases for sinking shafts as for driving galleries.

The Prussian rules for calculating the charges for mines are as follows:—

For common mines, that is for mines with two-lined craters, their rule is $\frac{l.\,l.\,r.^3}{10}$ S in lbs., the *l. l. r.* being the line of least resistance in ft., and S being the multiplier, varying according to the soil, and given in the following table:—

Description of Soil.	Multiplier or S.
For yellow sandy soil	1
For light sand with clay	1·2
For stiff sand	1·5
For earth with gravel	1·7
For very stiff clay	2·0
For brickwork, masonry, &c.	2·5 to 5

For mines with larger craters, their rule is as follows:—If n be the number of times the line of least resistance is contained in the required radius of crater, and l be the charge required for a common mine in that soil with the same line of least resistance, then the charge necessary to produce the larger crater required or $L = l\,(\cdot09 + \cdot91 \times n)^3$.† In this expression, if $n = 1\frac{1}{2}$, 2, $2\frac{1}{2}$, or 3, then the value of $(\cdot09 + \cdot91 \times n)^3 = 3\cdot08$, $6\cdot97$, $13\cdot23$, or $22\cdot43$ respectively. For example, the two mines fired on the 19th September, had lines of least resistance of 13 feet: they were required to make four-lined craters, and the soil was light sand with clay; l, or the charge for a common mine in that soil, $= \frac{13^3}{10} \times 1\cdot2 = 263\cdot64$ and $L = 263\cdot64\,(\cdot09 + \cdot91 \times 2)^3 = 263\cdot64 \times 6\cdot97 =$ 1837 lbs.

* This description of case has been a long time an article of store at the Woolwich Cadets' Field Work Instruction Ground. It was, I believe, invented by Staff Sergeant Instructor Minords, R.E.—Ed.

† This rule is almost identical with Macaulay's rule for overcharged mines, as modified in the present Woolwich Course Book. In it, if x be the line of least resistance, R the radius of the crater, L the charge for the overcharged mine, l that for a common mine with the same line of least resistance,

$$L = \frac{\{x + \cdot9\,(R - x)\}^3}{10} \text{ or if } R = nx \text{ (as above) and } l = \frac{x^3}{10}$$

$$= \frac{\{x + \cdot9\,(nx - x)\}^3}{10} = \frac{x^3}{10}\,(\cdot1 + \cdot9n)^3 = l\,(\cdot1 + \cdot9n)^3.\text{—Ed.}$$

APPENDIX J.

Iron Palisades.

Some experimental palisading was put up in the ditch of Gross Furst Alexander; it was made entirely of flat, angle, and T iron. There were two rows of palisades 8 ft. apart, and 8 ft. high out of the ground. The standards of T iron were placed at intervals of about 5 ft., and were sunk about 2 ft. into the ground. The standards of each row were connected together by three horizontal bars; one just above the ground, one near the top, and the third about a foot from the top. To these horizontal bars were riveted the palisades; nine between every two standards. In the front row, between the palisades, there were short pieces (riveted likewise to the two upper horizontal bars), the ends of which were pointed, and projected downwards for about a foot at an angle of 45°, thus serving as fraises, and preventing the assailants from making use of the horizontal bars to assist them over. Each standard of the front row was connected with the corresponding standard of the rear row by an iron bar at foot (under ground); and the two standards were, moreover, connected by two braces, secured to one at the ground line, and to the other at the head. The cost of this palisading (double row) was said to be about 10 shillings per foot lineal of ditch.

The Prussians keep in store, at every fort, the quantity of wooden palisading required for its defence; and it is believed to be under consideration whether economy would not be effected by adopting some kind of iron palisading. But the palisading above described was designed for the bottom of a ditch, the notion being that one or more lines of such obstacles in a ditch would materially assist in its defence. There also appeared to be an idea that it was worthy of consideration whether fortresses could not be constructed equally strong though at less cost, with several lines of palisading in the ditch (flanked, of course, by caponiers or counterscarp galleries), instead of with expensive escarp walls.

On the 3rd of September some experiments were made against the iron palisading that had been put up in the ditch of Gross Furst Alexander, which was there only 10 ft. wide at bottom, with escarp and counterscarp of earth at a slope of about 50°.

The first experiment was to see if the palisade could be demolished speedily by a working party. For this purpose a party of Pioniers, provided with sledge-hammers and other tools, advanced against it; but in seven minutes, they failed to make any serious impression on it.

The second experiment was to try the effects of gunpowder on it. It was re-

solved to use two charges of 40 lbs. each against two adjacent standards. Two 3-inch oak planks, 6 ft. long, were placed on edge, one over the other, against the lower part of the palisade, and the charges were laid against these planks; sand bags were piled against and over the charges, which were then fired simultaneously. The result was an opening, 15 ft. wide, in both front and rear row of palisades. It should, however, be borne in mind that the palisade hardly had a fair chance. Its situation was at the bottom of a very narrow ditch, and the charges were almost touching the counterscarp, which would increase their effect in the other direction.

APPENDIX K.

Duties of Trench Major; taken from the Austrian Regulations.

A Captain or Field Officer of Engineers is detailed (before the siege begins) as Trench Major.

1.—He is charged with the duty of collecting and arranging at the Engineer park all the stores, materials, &c., that may be required. For this purpose he is given such detachments of Infantry, Cavalry, and Train, as he may demand. Should the number of Government waggons be insufficient, he is to authorize the officers commanding these detachments to obtain the necessary transport by means of requisition on the inhabitants.

2.—The Trench Major is to have the entire control and management of the Engineer park, and of all the working parties (Pioniers as well as Infantry), who may be employed there. The labourers for the park having once been detailed from their regiments for this duty, remain permanently employed.

3.—The Trench Major is to have two officers told off to assist him in his duties, one of whom is always to be in the trenches, but the Trench Major must personally inspect the trenches as often as possible.

4.—The Trench Major's department is charged with the general police duties of the trenches, viz., the arrest and conveyance to head-quarters of all suspicious persons, &c.; the construction and maintenance of the necessary splinter-proofs in which the surgeons may attend to the wounded; the supply of drinking water to the various drinking places in the trenches; the collecting and removal to the park of all broken tools and implements; the erection of such notice-boards as may be necessary to facilitate the communication through the trenches; general charge of the cleanliness and sanitary regulations of the trenches.

5.—The Trench Major receives daily, in writing, from the Engineer Field Officer of the day or the senior Engineer in the trenches, all requisitions for materials required for the siege for the ensuing 24 hours. These requisitions are sent to the Director of the Attack, or in urgent cases, direct to the Engineer

Park. The materials are issued by the Storekeepers on the receipt of these requisitions, which are filed. The Trench Major also receives from the Director of the Attack a return shewing the numbers of the troops and working parties for whom it is necessary to prepare for the next day. The Trench Major, or one of his assistants, is always to be present in the trenches when the reliefs take place, so as to post them in their proper places without delay. Finally, the Trench Major is to keep the journal of the siege, in which the strength of all working parties, hours of relief, and work done, are to be noted. He also keeps the materials-and-requisition-journal.

APPENDIX L.

Passage of Wet Ditch.

This operation was carried on at the foot of the fortress of Ehrenbreitstein, across a wet ditch communicating with the Rhine. (See Pl. XIII.)

As it was not considered advisable to form a great gallery, and break through the counterscarp, a wooden section of a great gallery was set up in a ramp leading down to the level of the water in the ditch, a rough profile being made at its lower end, to represent the face of the counterscarp, supposed to have been broken through. In the sketches this profile is not shown, but in its place a counterscarp. The depth of the water next the imaginary counterscarp was 1 ft. 6 in., and the depth gradually increased to about 3 ft. or 3 ft. 6 in. There was no current in the ditch. The materials used were sand-bags, about 1 ft. square, loosely filled with earth (so as easily to accommodate themselves to any position), and weighing about 18 to 20 lbs. each; 6-feet fascines, with stones bound up inside them so as to cause them to sink; gabions, of the usual dimensions; bullet-proof planks, about 8 ft. long; and two standards, made of rough timber, 10 ft. high, to carry the planks forming the screen.

The counterscarp having been supposed to be blown in, a chain of Pioniers, placed about 6 ft. apart, was made down the great gallery; fascines were then passed down, and thrown into the ditch next the counterscarp, forming a foundation about 18 ft. wide, and 12 ft. to the front. Practically, this foundation would probably have been formed by the debris of the counterscarp.

As soon as the fascines were in sufficient numbers to show above the level of the water in the ditch, sand-bags were handed down the gallery, and thrown loosely on to the fascines so as to form a wall or parapet about 6 ft. 6 in. high; The slope of the parapet so formed being about 40° to the front, and rather steeper on the inside. This being completed, men were stationed inside to gradually remove the sand-bags, throwing them over the parapet to the front and sides, so as to form a sort of horse-shoe lodgment of sand-bags, about 5 ft.